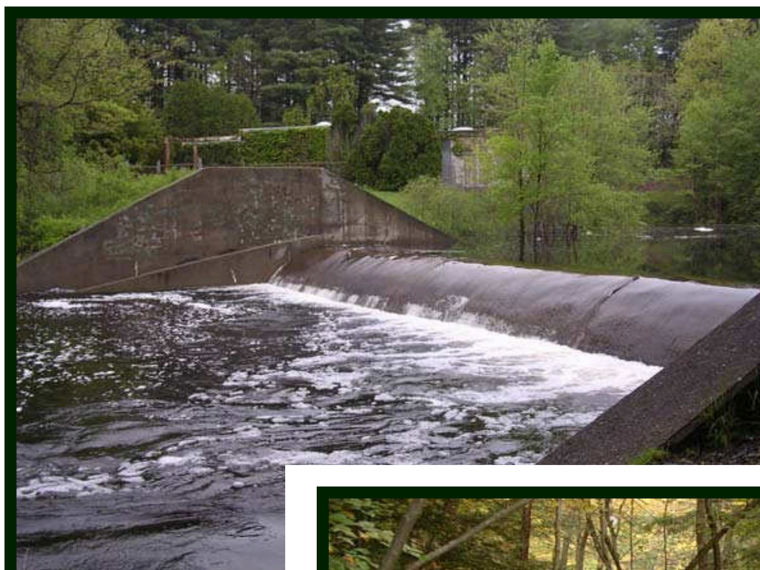
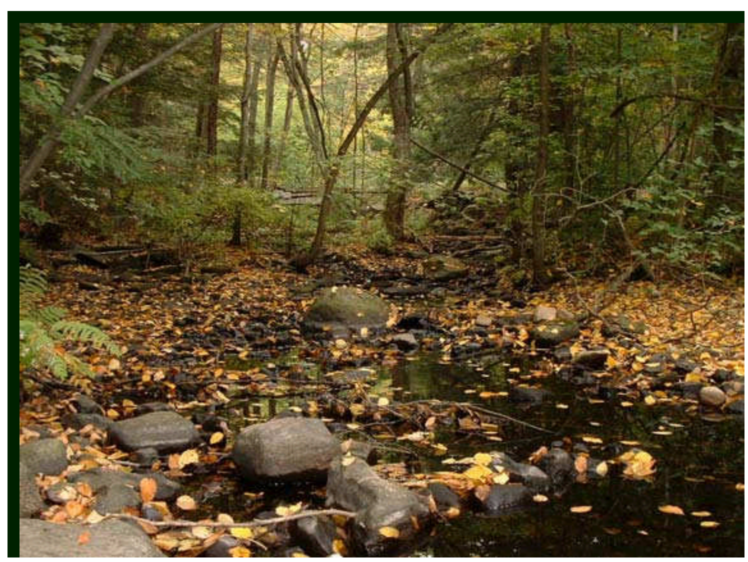
Town of Andover, Massachusetts

Fish Brook Initiative
Final Report

June 2006





Report

June 1, 2006

Board of Health
Board of Selectmen
Town Manager
Town Hall
36 Bartlett Street
Andover, Massachusetts 01810

Subject: Fish Brook Initiative Final Report

Dear Town Officials:

The Fish Brook Initiative Task Force is pleased to submit this final report. The16-person committee, appointed by the Board of Health and comprised of community residents and town staff with expertise in environmental pollution, water supply and public health, was assembled to examine potential threats to Fish Brook. The committee conducted an evaluation based upon protecting and preserving Fish Brook as an integral component of the Town's drinking water system. The task force addressed issues in a technical manner, performed a thorough assessment, and subsequently recommends Town action with the intent to preserve Fish Brook as a valuable economic and environmental resource.

Respectfully,
Fish Brook Initiative Task Force

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Cynthia Vaughn, Water Resources Manager
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Section 1
Introduction

1.1 Fish Brook Initiative

The Andover Board of Health (BOH), at its meeting on October 20, 2003, took initial steps to preserve and protect one of the town's vital environmental and economic resources; Fish Brook. This five-mile long stream is an integral component of the Town of Andover public drinking water system. Former Director of Public Health, Everett Penney, presented the BOH with data that indicated the town's water supply system was under assault from over-development along the entire length of Fish Brook. Pesticides and fertilizers from two golf courses, fractional distillates of gasoline (namely benzene, xylene, toluene and MTBE) in the groundwater of a service station, a Massachusetts Highway salt storage operation shed and road salt application on Interstates 93 and 495 all represented potential sources of pollution that threatened the Fish Brook. The BOH voted to establish a task force to address these issues and recruited community residents and town staff with expertise in environmental pollution remediation, water supply protection, and public health to join the FBI (Fish Brook Initiative) Task Force. The BOH envisioned the mission of FBI to be public education, surveillance, and enforcement in order to preserve Fish Brook as a valuable economic and environmental resource for the Town.

1.2 Fish Brook, Public Water Supply

The Fish Brook watershed covers 2,450 acres contained solely within the political boundaries of the Town of Andover, which is an important factor when considering watershed protection options. The brook arises in wetlands near Haggetts Pond and from the ponds in Indian Ridge Country Club. It flows roughly parallel to Interstate 93 and empties into a holding pond built at the Merrimack River.

During the late 1950s and early 1960s, a time of population growth in Andover, Haggetts Pond lacked sufficient capacity to meet the growing water demands of the population during peak times of the year. To solve the problem, the town built a dam at the mouth of the Fish Brook to create a holding pond in order to separate the Fish Brook water from the Merrimack River water. A pipe was installed connecting the holding pond to Haggetts Pond, approximately one mile upstream, and a pumping and chlorination station was constructed to chlorinate water and transport the water from Fish Brook to Haggetts Pond. This was done at certain times of the year to raise the water level of the pond, and thus increase capacity of the town water supply. During the 1970s, increasing population further depleted the water supply during peak times, and so it became necessary to supplement Haggetts Pond further by pumping water from the Merrimack River as well as Fish Brook to the reservoir.

Today, the mouth of Fish Brook has been dammed to retain its flow. A pump station located at the dam delivers water through a 24-inch water line upstream to Haggetts Pond. The Fish Brook Pumping Station is managed as a reservoir without storage capacity. Thus water is available for capture, but not storage, and the inflow to Haggetts Pond is measured by flow data from the combination of both Fish Brook and Merrimack River water supplies.

Section 2
Regulatory Protection of Fish Brook

2.1 Massachusetts Surface Water Quality Standards

The Massachusetts Department of Environmental Protection (DEP) adopted the Massachusetts Surface Water Quality Standards (SWQS) in May 1997 to designate how various waters of the Commonwealth shall be enhanced, maintained and protected. Surface waters are assigned a "Class" with each identified by the most sensitive, and therefore governing, water use to be achieved and protected.

Fish Brook, as a Public Water Supply, is designated for protection as a Class A water body under 314 CMR 4.06, which constitutes it as an outstanding resource as determined by its socio-economic, recreational, ecological and/or aesthetic values. This Class A status requires that Fish Brook be protected from pollutants in concentrations or combinations that are toxic to humans, aquatic life, or wildlife. With specific pollutants, such as arsenic, that can reasonably be expected to adversely effect designated uses, DEP assigns the recommended limit published by the Environmental Protection Agency in the Federal Act as the allowable receiving water concentration.

The Massachusetts SWQS prescribe minimum water quality criteria required to sustain designated uses of our water resources, and the regulations necessary to achieve the designated uses and maintain existing water quality.

2.2 Massachusetts General Law

The General Laws of Massachusetts Part I. Title XIV Public Ways and Works Chapter 85 states regulations and by-laws relative to ways and bridges. Section 7A defines law relative to the storage and use of snow removal chemicals. Specifically, "No person shall store sodium chloride, calcium chloride or chemically treated abrasives or other chemicals used for the removal of snow or ice on roads in such a manner or place as to subject a water supply or groundwater supply to the risk of contamination." The word "person" as used in this section includes the chief engineer of the state department of highways, and the chief administrative officer of state agencies. This law also establishes reporting requirements for the use and storage of such chemicals, and penalties for violation.

2.3 Town of Andover Bylaw

Article VIII Section 8 of the Andover Zoning By-Law locally defines and regulates a Watershed Protection Overlay District (WPOD) that was established December 1986 for the following purposes:

- To preserve and protect surface and ground water resources for the health, safety and welfare of its people; and
- To protect the community from the detrimental use and development of land and waters within the watershed.

The Fish Brook/Haggetts Pond watershed includes all the lands that create the catchment or drainage areas of Fish Brook or Haggetts Pond as part of their natural or man-made drainage system. The by-law prohibits the location of landfills and the storage of salt and road de-icing chemicals within the WPOD.

Section 3
Tasks of the Fish Brook Initiative

3.1 Identification of Potential Threats

The Fish Brook Initiative Task Force identified the following as potential threats to the public drinking water supply:

- Golf courses
- Mobil Oil Gasoline Station
- Mass Highway salt storage shed
- Ledge Road landfill
- Homeowner activities

3.2 Sampling, Analysis and Data Compilation

The Task Force developed a water-quality monitoring program in response to contaminants of concern related to the specific land uses identified above. The program identified the types of water quality problems and pollutant sources that would likely be encountered. Six (6) sampling stations were established along Fish Brook and assessment techniques were defined that would examine the overall health of Fish Brook. A multitude of chemical parameters were monitored over a period of time in order to account for anticipated seasonal variations. To a large extent, analyses were performed at the water treatment plant laboratory by a certified chemist using state certified procedures. Some samples were sent out to contracted laboratories for testing that could not be performed in-house. Committee members periodically compiled the data to determine further testing schemes.

3.3 Protection Efforts

The Fish Brook Initiative was not only charged with the task of identifying and reporting potential threats to Fish Brook, but also asked to implement protection measures in order to preserve it as an important local resource. The committee assumed various means of protection and brief summaries of those efforts follow. More detailed reviews are contained in the appendices.

3.4.1 Mass Highway (MHD) Salt Shed Meetings

In 1998, MHD relocated a major salt storage shed to the area abutting the northbound connector between Interstates 93 and 495, located along the northeastern edge of the Fish Brook watershed. Initially, the MHD's best management practices (BMPs) were not followed, resulting in apparent major discharges of sodium chloride to the Fish Brook aquifer. During the years between 1998 and 2003, the sodium level in Andover's finished drinking water more than doubled, rising from 32 ppm to 70 ppm, more than three times the Environmental Protection Agency recommended level for drinking water. As discussed in Section 1, this situation triggered the creation of the Fish Brook Initiative Task Force. The Task Force identified the salt storage shed as a *major* contributor to the increased sodium levels and thus began communications with Mass Highway officials to rectify the problem. MHD accepted responsibility and began implementation of better site control methods. Continued discussions led to the designation of a "Reduced Salt Area" along highway sections within the Fish Brook and Haggetts Pond watersheds. The ultimate objective of the Task Force regarding this issue has been, and remains, the relocation of the salt storage shed. To date Mass Highway officials have verbally committed to moving the storage shed. The proposed relocation site is the River Rd. interchange. Announcement of a design RFP is expected this summer.

3.4.2 Landfill Public Involvement Process (PIP)

The Ledge Road landfill stopped accepting waste other than brush in 1973. Since 1992, only the Town disposes of brush on the property (see Appendix D for more detail). Leachate from the landfill, which is substantially closed but is not fully capped, was determined to contain elevated levels of heavy metals such as iron and arsenic. Groundwater and surface water analyses indicated the presence of volatile organic compounds such as benzene and trichloroethylene, semivolatile organic compounds, and pesticides. In addition, sediments in and adjacent to small streams that flow from the landfill area into Fish Brook were found to hold high levels of precipitated arsenic. Elevated levels of heavy metals were detected in soils as far as ½ mile from the landfill.

The Fish Brook Initiative Task Force regards the Ledge Road landfill as a significant current threat to the drinking water supply. The Task Force held several meetings with Camp, Dresser & McKee (CDM), the consultant firm handling the landfill closure project. In earlier reports, CDM falsely identified the location of the landfill in relation to the public drinking water supply. That error resulted in an inaccurate Comprehensive Site Assessment of the landfill. The Task Force supported the initiation of a Public Involvement Process (PIP) through the Department of Environmental Protection in order to oversee decision-making performance and action for proper landfill closure.

Risk analysis of various remediation options for the current contamination is ongoing. Continued monitoring of groundwater, surface water, and sediment is integral to the closure process. The Task Force has contributed to the sampling, analysis, and technical assessment of the landfill closure project.

3.4.3 Outreach, Middle School Project

Over 100 students from the Wood Hill Middle School, in a Community Link Project, used their academic curriculum to study Fish Brook. The learning expedition was a yearlong project that challenged students in content and skill through an in-depth investigation of a topic that engaged them with authentic projects, fieldwork, and service. The expedition was designed to build a strong connection to the world outside of the classroom to make learning relevant, while providing a service to the community. Working with the Andover Water Department, the Fish Brook student investigators determined human impacts on their watershed. Students sampled Fish Brook throughout the school year and tested it for contamination. They recorded environmental conditions and determined the amount of water that flows from Fish Brook into our drinking water supply. Throughout the school year, students learned about watersheds and the importance of water quality in their community. Their information was shared with the Water Department and presented at the spring Town Meeting along with suggestions as how to protect the Fish Brook Watershed.

3.4.4 Mobil Oil Gasoline Station

The Mobil gasoline station at the juncture of Route 133 (Haverhill Street) and the exit/on-ramps to I-93 is a designated hazardous waste site, due to leaking underground gasoline storage tanks. The site has remediation equipment in place, capturing and filtering the contaminant plume before it leaves the property. The site is close to and drains toward Fish Brook. There have been numerous equipment failures, so ongoing oversight by the Town Health Department is required. This station is one of the three busiest Mobil stations in the Boston area, so closing the station would be difficult. The Task Force reviewed technical reports produced by CDM, the firm managing the waste cleanup process, and met with CDM engineers who provided an overview of the system status. The Mobil Station is in Remedy Operation Status, which means remedial measures are being implemented to achieve a permanent solution or site closure. There are continued failures of the Vacuum Enhanced Groundwater Extraction system (VEGE) and similar operational issues with the Soil Vapor Extraction/Air Sparging system (SVE/AS). The Task Force sees the present remedial action as deficient because of the less than full time operational status, and has advocated plans to upgrade the current system.

3.4.5 Golf Courses

Several small lakes/ponds are located on the Indian Ridge Golf Course, which may accumulate pesticide and herbicide residues from the continual high maintenance of the land. Groundwater and surface water from the property flows into the headwaters of Fish Brook. The cost of pesticide and herbicide monitoring and analysis is very high and, therefore, the Task Force was limited in its ability to examine such contamination. No pesticide or herbicide residue was detected during the committee's one time water monitoring, but seasonal applications may justify additional monitoring, as many pesticides have health impacts and are designed to be persistent in the environment.

3.4.6 Homeowner Activity

Individuals applying pesticides and fertilizers to their lawns, or improperly disposing of wastes such as used motor oil down catch basins can also pose a risk to the watershed. Public purchase of land in the Watershed Protection Overlay District, as well as public information outreach is intended to help protect against this type of risk. The Fish Brook Initiative members routinely provided, in collaboration with the Health Department and the League of Women Voters, public education and outreach on such issues to encourage residents of the Andover community to minimize their negative impact to the drinking water supply.

3.4.7 Salt Balance RFP For Consulting Services

The Task Force, through the Board of Health, initiated a warrant article for the 2005 annual town meeting. The town voted to appropriate the sum of $20,000 for the purpose of engaging the services of an environmental consultant to perform a mass salt balance analysis in the Fish Brook and Haggetts Pond watershed areas. A RFP was issued, a consultant selected, and the project is scheduled to commence in May 2006. The project will produce a mass salt balance of inputs to the drinking water supply system and issue a report of recommendations to protect the public health.

Section 4 Salt Evaluation

From November 2004 to May 2005 the FBI conducted an evaluation of the salt load in Fish Brook. The principal purpose of the evaluation was to develop a baseline understanding of Fish Brook salt loads along the length of the brook, and to establish a stream-gauging network for long-term trend evaluation. The data developed during this evaluation can be used to monitor anticipated improvements in water quality in the brook resulting from implementation of a low-salt application designation for the Fish Brook Watershed.

4.1 Procedure

The basic procedure for evaluating the load of any chemical in a flowing stream or brook is to measure both the stream flow rate and the concentration of the chemical of interest at the same time. The total quantity or "load" of the chemical of interest is determined by multiplying the stream flow rate by the chemical concentration. The resulting "load" is an expression of the total amount of the chemical of interest that is carried in the stream at a particular location over a fixed period of time. Therefore, the units for "load" are expressed as mass/time, and are commonly presented as pounds/day or tons/year.

The evaluation of Fish Brook focused primarily on the sodium load in the brook. Sodium chloride load was also estimated for comparison to salt application totals in the Fish Brook watershed.

4.1 Flow Measurement

The FBI selected four primary stream gauging locations along the brook:
FB-1 Greenwood Road Crossing
FB-2 High Plain Road Crossing
FB-5 River Road Crossing
FB-6 Upstream of Fish Brook/Merrimac Intake Structure

These gauging stations were selected primarily due to ease of access.

The committee installed a staff gauge at each stream gauging station (shown photo below). Staff gauges are used simply to record the level or elevation of the stream at any point in time. To determine flow rate it is necessary to measure the actual stream flow on several occasions, and then develop a correlation between staff gauge measurement and flow rate. With the correlation established the stream flow rate could be reliably estimated using only the staff gauge reading.

FBI members measured stream flow on several occasions throughout the study period. Measurements were made using an electronic velocity meter purchased for the committee's use. Flow measurements were made in general accordance with procedures established by the United States Geologic Survey (USGS). Correlations between flow rate and staff gauge reading for the four gauging locations are depicted in Figures 1 through 4 contained in Appendix C.

4.2 Estimation of Salt Load

The FBI committee estimated sodium and sodium chloride loads in Fish Brook using the data included in Table 1 of Appendix C. The load estimates are also included in Table 1, and are expressed in units of lbs/day and tons/year. Graphs of the sodium load at each station throughout the study period are shown in Figure 5 of Appendix C.

4.3 Observations

The FBI presents the following observations regarding the sodium load evaluation presented above:

- Measured sodium concentrations in Fish Brook during the study period ranged from 32 mg/l to 330 mg/l.

- Sodium load in Fish Brook during the study period ranged from a low of 16 tons/year to a high of 8,422 tons/year

- Sodium load generally increases in the direction of stream flow (i.e. as water flows down the brook the amount of sodium in the stream increases.)

- Sodium concentration does not always increase in the direction of stream flow due to the diluting affect of increasing flow.

- A large increase in sodium load was documented between FB-1 and FB-2 where Fish Brook crosses Interstate Highway 93 (I-93) near its intersection with I-495 (and the Massachusetts Highway Department's salt storage shed).

- The sodium load downstream of I-495 was observed to show only slight further increase. This is presumed to be due to the lack of significant sodium sources after the stream crosses I-495.

- The average sodium load in Fish Brook at its confluence with the Merrimac River was approximately 5,100 tons per year during the study period. This value can be compared to annual salt application within the Fish Brook watershed.

Section 5 Landfill Assessment

5.1 History

The Andover Town Landfill is an unlined former stone quarry that began use as a municipal waste dump accepting both residential and industrial wastes after the close of World War II. Open dumps and burning of trash were acceptable methods of dealing with solid waste at that time. Companies such as Reichold Chemical, Gillette, Raytheon, Converse, and Tyer Rubber were regular users of the landfill/dump. In 1972, the Massachusetts Department of Public Health (MA DPH) determined that leachate from the landfill was polluting a brook that was upstream of a surface water drinking water intake operated by the Town of Andover. Analytical results of leachate samples collected by MA DPH indicated the presence of zinc, chromium, and other metals. Later in 1972, MA DPH ordered the Town of Andover to close the landfill and to construct piping and works to divert and control groundwater entering the landfill and to substantially eliminate the flow of leachate to the brook. A drain was subsequently installed in 1972 to intercept groundwater flowing into the landfill. In 1973, the landfill stopped accepting waste, with the exception of brush from Andover residents, which was accepted until 1992. The Town of Andover capped the landfill with one foot of clay and five feet of loam fill in 1988 and subsequently developed a portion of the property as an outdoor athletic facility.

Environmental monitoring of surface water, groundwater and sediment has been ongoing since the 1980s. The wetlands down gradient of the landfill drain toward Fish Brook, and as such are considered a Class A surface water under DEP regulations. Although VOCs, SVOCs and a number of metals have been detected in surface water and groundwater, arsenic was identified as the contaminant of concern in evaluating potential impacts to human health. More detailed history concerning the dump is presented in Appendix D of this report.

5.2 General Background on Landfill Affects on Groundwater and Surface Water

Leachate from landfills (the liquids emanating from them) tends to be reducing (contains limited amounts of oxygen). In unlined landfills this leachate comes into direct contact with groundwater that in turn becomes reducing. Covers or impermeable soils such as clay on landfills also limit high oxygen rainwater infiltration, further limiting the amount of oxygen in groundwater.

The prevalent forms of iron and arsenic in oxygenated groundwater and surface water are the insoluble forms (stays as a solid and tends not to dissolve in water). However, in reducing environments with high organic content, the dominant forms of iron and arsenic are the soluble (dissolves readily into water) forms. Therefore it is not uncommon to have elevated iron and arsenic concentrations in groundwater near landfills. The reduced form of arsenic is arsenite, which is the most toxic form, and is soluble and hence quite mobile in groundwater. Therefore elevated arsenic and iron will migrate in groundwater from a landfill until the groundwater is diluted by oxygenated, unimpacted groundwater or surface water where the iron and arsenic will be oxidized. The oxidized form of arsenic is less soluble (and less toxic) and will tend to adhere to soils, precipitate, and have limited potential for further migration.

5.3 Existing Environmental Status and FBI Actions

The FBI is concerned that leachate from the landfill is migrating to groundwater, surface water or sediment. Contaminants in groundwater and surface water have the potential to migrate downstream and ultimately reach the source water intake (3 miles down gradient) where Fish Brook discharges to the Merrimack River. In early 2005 the FBI evaluated historical environmental data from the landfill to determine the extent of the problem and discuss the status of the environmental monitoring program with CDM, the Town's Environmental Consultant. As a result of a meeting with CDM, the FBI expressed serious concerns that the landfill was not being adequately monitored as arsenic levels in down gradient surface water, groundwater and sediment samples were approaching or exceeding the maximum contaminant level for arsenic of 50 ug/L. Furthermore, the maximum contaminant level (MCL) standard for arsenic was scheduled to be reduced by EPA in January 2006 to only 10 ug/L. Additionally, although not likely a human health concern, elevated iron levels in surface water have been observed as significantly reddish-orange water in the wetlands.

A second meeting between the FBI and CDM was held to determine a course of action to augment environmental monitoring of the landfill. Based on results of this meeting CDM conducted additional environmental monitoring activities along with normal scheduled sampling rounds; results were presented in a December 2005 report. Additionally, the FBI conducted surface water sampling.

Surface water samples were collected by the FBI at locations down gradient of the landfill and were analyzed for arsenic. These results indicated a range of arsenic concentrations from "none detected" to 16 ug/L. The maximum concentration was collected from SW-4.

Results of the CDM work in 2005 indicated:

- Groundwater results indicated arsenic concentrations in down gradient locations from the landfill exceed the MCL of 10 ug/L. The highest detected concentration was 63 ug/L at CDM-2S.

- CDM's report states that surface water results for arsenic concentrations only slightly exceeded the MMCL of 10 ug/L. However, these locations were only 200 ft down gradient of the landfill. At locations further downstream, concentrations were below the MMCL. The FBI notes that the MMCLs are Massachusetts Maximum Contaminant Level for groundwater and don't apply to surface water concentrations. The EPA has nationally recommended aquatic water quality criteria (AWQC) for the protection of aquatic life and human health in surface water. The concentration for chronic levels of arsenic in surface water is 150 ug/L (chronic exposure); however, the arsenic standards for surface water are still under EPA review and require a more comprehensive risk assessment to determine actual risk.

- Sediment results indicated elevated levels of arsenic in the most down gradient locations tested (SD-4 and SD-5). These locations had higher concentrations than those detected in sediments closer to the landfill. These results could be due to the discharge of arsenic impacted groundwater migrating from the landfill and discharging to the stream. The FBI notes that arsenic in groundwater that is reducing (lack of oxygen) will precipitate to a less soluble form of arsenic under more oxidizing (abundance of oxygen) conditions that occurs in surface water. This could result in adsorption (sticking to) the stream sediments and not be available to surface water as evidenced by surface water results. However, the extent of arsenic in stream sediments was not determined.

5.4 CDM Recommendations for Future Activities

1. Perform sampling on the Park property for which historically access has been denied.
2. Conduct additional sediment sampling at locations further down gradient than were sampled historically and in 2005.
3. Determine the actual risk posed by concentrations of contaminants in surface water.
4. Re-evaluate the human health risk based on the lower arsenic standard.
5. Prepare reports to address future management of groundwater, surface water and sediment around the landfill.
6. Assess the impact of a final cap on continued migration of contaminants from the landfill.
7. Add surface water sampling at down gradient locations on a more frequent basis.

5.5 FBI Recommendations for Future Activities

1. Conduct further review of the actual area considered to be part of the Andover Town Landfill. Information gathered from long-time residents indicates residential and industrial wastes were dumped in an area bordered by Chandler Road, Greenwood Road, and Ledge Road. Since this area is up gradient from the area now being considered by the Town for capping, this uncapped area of the landfill may compromise the effectiveness of the proposed cap.
2. Complete an updated human health and ecological risk assessment of the arsenic in groundwater, surface water and sediment down gradient of the landfill.

3. Re-evaluate the design, intention and future impact of a poorly maintained piping system often referred to as “under drains” installed around the landfill needs to be examined. It appears the designers of this system wished to divert groundwater around the landfill and the land bordered by Chandler, Ledge and Greenwood Roads.

Section 6 Recommendations

The task Force performed a detailed review of Fish Brook and its watershed in order to identify means and methods that would aid in preserving it as a valuable economic and environmental resource of the community. The actions recommended below are intended to safeguard Fish Brook as an integral component of Andover's drinking water supply.

6.1 Continue Monitoring of Fish Brook

A permanent monitoring station should be established in the vicinity of the Fish Brook Pumping Station to ascertain short term and long term impacts associated with winter deicing operations on interstate and state highways and highway interchanges that exist within the Fish Brook watershed. The permanent station should incorporate digitally based flow and water quality measuring devices that allow the use of data logging hardware and software in transmitting real time data directly to the Water Treatment Plant operations center. On the short-term basis, the resulting data stream could be used as a decision-making tool to assist the plant operators in controlling the quantity and quality of water pumped from the Fish Brook Pumping Station. For the longer term, an analysis of the data received would help correlate winter deicing practices within designated Low Salt Areas with sodium levels measured within the Fish Brook watershed area.

6.2 Continue Dialogue with Massachusetts Highway Department (MHD)

During 2004 and 2005, the Board of Health and members of the FBI Task Force attended meetings with MHD representatives to explore possible actions that would reduce sodium levels measured at several sampling points along Fish Brook. The MHD urged the Town to continue assembling a database that would document sodium levels found in Fish Brook. As a result of additional Town-sponsored monitoring and additional meetings and discussions, MHD designated a Low Salt Area along I-495, I-93, and State Route 133 contained within the Fish Brook watershed. In addition the MHD committed to taking the actions necessary to relocate the current MHD Salt Storage area to the River Road Interchange in Andover (outside the Fish Brook watershed area).

Given these successful actions, the Town should reinstitute the monthly meetings with MHD representatives to ensure that promised actions regarding the Salt Storage area relocation are realized. In addition, the Town and MHD should share water-quality data as they pertain to sodium levels measured at key locations adjacent to the highway corridors and along Fish

Brook to ascertain the effects of modified deicing practices intended to reduce sodium discharges to the Fish Brook Watershed.

6.3 Initiate a Review of the Town's Deicing Practices

As the environmental results from winter deicing practices within designated Low Salt Areas on interstate, state, and local highways become available, the benefits of reduced salt applications should be discussed with the Town's Public Works Department. Existing deicing practices should be reviewed with an emphasis towards finding ways to reduce salt application on local roads that exist within the Fish Brook and Haggetts Pond watersheds.

6.4 Continue Review of Landfill Closure Actions

The Town of Andover demonstrated its continuing commitment to environmental protection and improvement by approving funding at the Spring 2006 Town Meeting for designing the closure and cap for the former Town Landfill located adjacent to Chandler and Ledge Roads.

The landfill closure will serve to reduce potential pollutant releases to Fish Brook and enable the Town to reuse the site for recreational purposes. There is a need to review progress on the closure design to ensure that the following issues are addressed:

1. How will the existing landfill under-drain system impact long term ground water flow and quality?

2. Are there solid wastes or hazardous substances present in the land area circumscribed by Ledge, Chandler, and Greenwood Roads? If so, how will the landfill closure design incorporate the identified area?

3. How will the current Town policy of street sweepings and storm drain residue disposal at the former landfill impact the closure plans?

6.5 Continue Citizen Involvement at Fish Brook

Based on the findings and recommendations of the FBI Report, the Town should appoint a standing committee that continues the mission of the FBI Task Force. The Town should also consider expanding the scope to include review and oversight of the entire Town watershed area, including Haggetts Pond.

APPENDIX A

MOBIL GASOLINE STATION
309 Lowell Street

The Mobil gasoline station, which lies within the Fish Brook and Haggetts Pond watershed, was identified by the Fish Brook Initiative as a potential source of pollution to Fish Brook. The Mobil station is located on the north side of Lowell Street (Route 133) across from the Internal Revenue Service complex approximately 1/2 mile northeast of Interstate 93. A hotel and golf course border the west and north sides of the station and to the east is undeveloped land. A tributary to Fish Brook flows directly north of the station. The stream flows intermittently and receives stormwater runoff from the nearby roadways. This stream flows into a ponded area and ultimately flows into Fish Brook. Fish Brook is approximately 1000 feet north of the station. Both the tributary and Fish Brook are designated Class A surface waters.

The location of the current Mobil station has been a gasoline dispensing station since 1959. Vehicle repairs were also conducted until 1986. In 1989, the service area was converted to a convenience store. The gasoline underground storage tanks (USTs) were removed and replaced with fiberglass tanks in 1982. The station piping was recently upgraded but this activity did not include replacing the tanks or any data collection.

A release of gasoline was discovered in 1989 during removal of an underground fuel oil storage tank near the eastern corner of the station building. MassDEP assigned Release Tracking Number (RTN) 3-3072 to this release. Since then, a number of investigations by various consultants have been conducted to identify sources of contamination and determine their extent. The investigations have concluded that the primary source of gasoline was releases from the underground storage tank (UST) area (which has remained in the same area since 1959) and gasoline dispensers. Free phase gasoline was detected in one monitoring well (MW-2) in 1991 and 2001, the latter occurrence possibly a result of a 1996 leak in a flex connector hose. Additional releases also likely occurred from an oil/water separator and dry well, which received runoff from around the pumps.

In 1998, the gasoline additive Methyl Tertiary Butyl Ether (MTBE) was detected in the tributary behind the station and also in Fish Brook. This condition triggered upgrades to the groundwater recovery and treatment system. Groundwater from the station flows north toward Fish Brook. Several surface water sampling stations have been established including two in Fish Brook (SW-4, SW-7). MTBE has been detected in the stream adjacent to the station on several occasions but has not been detected in Fish Brook since February and March of 2000. A groundwater plume of MTBE has migrated north from the station to the furthest downgradient wells (OW-R, OW-S) but has been shrinking since 2001.

Cleanup activities began in January of 1991 with the installation of a groundwater extraction and treatment system. Three recovery wells were installed in the northeast corner of the property. But the treatment system has not operated reliably, particularly in the winter. The system operated from 1991 to 1996 and then was shut down until 1998. The treatment system has been upgraded a number of times, including the addition of vapor extraction in 1993-1994. In 1998 the system was upgraded to its current configuration of 7 groundwater extraction wells, several legs of air sparge and soil vapor extraction and is currently "winterized". Treated groundwater is discharged into the sanitary sewer system. The configuration of extraction wells is designed to intercept the plume just north of the station building and to address the source areas. Improvements have also been made to the storm water collection system.

The site is in Remedy Operation Status, which means remedial measures are being implemented to achieve a permanent solution or site closure. Operation and maintenance activities include bi-monthly inspection of the treatment systems, bi-annual sampling of the groundwater monitoring wells (currently 25 monitoring wells are sampled) and surface water sampling once per year.

Representatives of Camp Dresser & McKee, Inc. (CDM) provided an overview of the site to the committee on September 28, 2004. The site is a public involvement plan (PIP) site with report being sent to the Health Department and Memorial Hall Library on a regular basis. A comment letter was sent to CDM after the meeting. The committee recommended collecting soil samples to better evaluate the source areas.

The remedial systems appear to be slowly cleaning up the site and current conditions do not pose a threat of contamination to Fish Brook. However, residual soil contamination in source should be determined as part of the overall evaluation of the remedial systems' effectiveness. The station should continue to be monitored periodically by the town to ensure continuation of the cleanup and identify any new spills or releases, which might change conditions.

APPENDIX B
PESTICIDES

The Pesticide Reduction Task Force was established by the Andover Board of Health on January 6, 2003, and culminated in the adoption of the Town of Andover Policy of Pesticide Use in July 2003. The 12-person committee focused attention on the issue of pesticides in several ways:

- Joyce Ringleb and Diana Walsh attended the town fields committee meetings with Randy Pickersgill, the Superintendent of Plant and Facilities, encouraging the group to minimize use of pesticide products on playing fields and to improve signage informing the public of pesticide applications so that field use can be avoided during periods of treatment.
- Joyce Ringleb and Amy Janovsky invited the group to attend a Healthy Lawns and Landscapes forum sponsored by the League of Women Voters of Andover/North Andover, regarding health issues relating to pesticide use. The tape resulting from the workshop was made available to Andover's cable TV studio for broadcast.
- Cynthia Vaughn, DPW, suggested establishing 6 monitoring locations to monitor for potential surface runoff of pesticides that could impact Andover's drinking water supply. She agreed to do this.
- Lisa Treadwell and Amy Janovsky reviewed Pesticide Use Surveys prepared by Wellesley, MA and the Center for Ecological Technology (CET) in Pittsfield, MA. They then drafted a questionnaire on pesticide use in Andover, which was distributed to groups of residents at Town Meeting and at various sporting events over a period of several weeks.
- Roberta Whitney tabulated the responses from 50 of the surveys received:

    1. 2% of the respondents tested their soil annually, 76% never, 22% once
    2. 80% maintained their own lawns
    3. Most commonly used products were: fertilizers (72%), lime (56%) and bark mulch. For weed control: Roundup and dandelion/crabgrass control were each used by 28%; for insect control 36% applied grub control.
    4. 28% of the respondents reported using less lawn care chemicals than in the past, 32% used about the same as in the past.
    5. 36% of the respondents received information about lawn/garden products from books/magazines, 36% from garden centers, and 26% from their landscaper or lawn care company.
    6. 48% watered by hand (hose or sprinkler) and 34% rain only.
    7. 56% of the respondents compost leaves, 46% compost grass, 36% do not compost.
    8. 42% responded that they would be willing to receive follow-up call from the task force and an equal 42% were not willing to be called.

Note: a final tabulation of all surveys was completed by Maria Bartlett but is unavailable in the files.

- IPM plans for all 8 schools were filed with the state. The Health Director must be contacted for "emergency" pesticide use in or around schools
- Randy Pickersgill announced that spot treatment for grubs and other pests would continue on town playing fields due to demand by sports organizations in town. Signage must be provided.

Recommendations:

The group was dissolved following adoption of the Pesticide Use Policy, but several items were proposed but never completed:

- The group recommended visiting the issue in a few years to see if the Town wishes to implement regulations regarding pesticide use to further implement the goals of the Policy. (See attached article on Marblehead's adoption of regulations).
- DCS offers an annual lawn care class that is well attended. The group strongly recommends that future classes stress IPM/organic lawn care strategies in accordance with the Town Policy, in order to better protect human health and water resources in town.
- The group expressed interest in a demonstration "Living Lawn and Gardens" demonstration site showcasing successful approaches to using water conservation and organic lawn care practices. Ben & Gerry's has funding available for this type of project.
- Continued Cable TV showings of tapes on organic lawn care.
- Participation with attendance at future League of Women Voters Organic Lawn Care Fairs
- Consider NOFA certification for DPW staff, specifically Superintendent of Grounds.

APPENDIX C
SODIUM DATA

TABLE 1 - SODIUM LOAD SUMMARY

Date	Location	Staff Gauge Reading	Estimated Flow Rate	Sodium Concentration	Sodium Load		Sodium Chloride Load	
		(feet)	(cfm)	(mg/l)	(lbs/day)	(tons/year)	(lbs/day)	(tons/year)
11/12/2004	FB-1	1.5	19	49.1	85	16	217	40
11/30/2004	FB-1	1.68	49	63	275	50	698	127
1/4/2005	FB-1	2.1	415	123	4580	836	11642	2126
1/10/2005	FB-1	1.74	66	330	1954	357	4966	907
1/14/2005	FB-1	2.54	3923	97	34180	6242	86887	15868
1/25/2005	FB-1	1.85	116	43	447	82	1135	207
2/1/2005	FB-1	1.66	44	52	205	37	520	95
2/8/2005	FB-1	1.68	49	67	292	53	742	136
2/19/2005	FB-1	1.88	135	100	1210	221	3077	562
3/15/2005	FB-1	1.74	66	247	1462	267	3717	679
3/28/2005	FB-1	1.84	110	71	701	128	1781	325
5/5/2005	FB-1	1.66	44	61	240	44	610	111
5/16/2005	FB-1	1.8	90	65	523	95	1329	243
5/26/2005	FB-1	2.42	2125	32	6109	1116	15529	2836
11/12/2004	FB-2	1.44	375	79.1	2665	487	6775	1237
11/30/2004	FB-2	1.4	341	67	2050	374	5211	952
1/4/2005	FB-2	1.34	289	98	2544	465	6468	1181
1/10/2005	FB-2	1.6	514	130	5998	1095	15246	2784
1/14/2005	FB-2	1.7	601	166	8956	1636	22767	4158
1/25/2005	FB-2	1.15	126	130	1477	270	3753	685
2/1/2005	FB-2	1.04	33	114	337	62	856	156
2/8/2005	FB-2	1.06	50	206	923	169	2346	428
2/19/2005	FB-2	1.56	479	117	5033	919	12794	2337
3/15/2005	FB-2	1.34	289	216	5608	1024	14256	2603
3/28/2005	FB-2	1.54	462	98	4063	742	10329	1886
5/5/2005	FB-2	1.22	186	112	1873	342	4762	870
5/16/2005	FB-2	1.16	135	111	1346	246	3421	625
5/26/2005	FB-2	2.46	1274	54	6178	1128	15705	2868
11/12/2004	FB-5	1.44	181	93.4	1517	277	3855	704
11/30/2004	FB-5	1.8	588	70	3699	676	9403	1717
1/4/2005	FB-5	1.92	771	96	6644	1213	16890	3084
1/10/2005	FB-5	1.7	454	113	4610	842	11717	2140
1/14/2005	FB-5	3.04	3590	143	46115	8422	117224	21408
1/25/2005	FB-5	nm	nm	141				
2/1/2005	FB-5	1.66	405	118	4293	784	10912	1993
2/8/2005	FB-5	1.58	314	151	4265	779	10841	1980
2/19/2005	FB-5	2	905	100	8128	1484	20662	3773
3/15/2005	FB-5	1.72	480	197	8488	1550	21577	3940
3/28/2005	FB-5	1.92	771	201	13911	2541	35363	6458
5/5/2005	FB-5	1.6	336	158	4770	871	12126	2214
5/16/2005	FB-5	1.48	216	113	2190	400	5566	1017
5/26/2005	FB-5	3.1	3798	80	27294	4985	69381	12671
11/12/2004	FB-6	4.3	286	75.8	1947	356	4948	904
11/30/2004	FB-6	4.75	811	70	5101	931	12966	2368
1/4/2005	FB-6	4.88	997	88	7879	1439	20028	3658
1/10/2005	FB-6	4.85	953	nm				
1/14/2005	FB-6	5.65	2406	94	20318	3711	51649	9432
1/25/2005	FB-6	nm	nm	65			0	
2/1/2005	FB-6	4.7	744	115	7684	1403	19533	3567
2/8/2005	FB-6	4.7	744	137	9154	1672	23269	4250
2/19/2005	FB-6	nm	nm	100			0	
3/15/2005	FB-6	4.66	692	171	10623	1940	27004	4932
3/28/2005	FB-6	4.98	1150	99	10225	1867	25991	4747
5/5/2005	FB-6	4.52	520	103	4811	879	12230	2234
5/16/2005	FB-6	4.36	345	114	3537	646	8992	1642
5/26/2005	FB-6	6.25	3873	114	39662	7243	100820	18412

NOTES:

1. nm = not measured

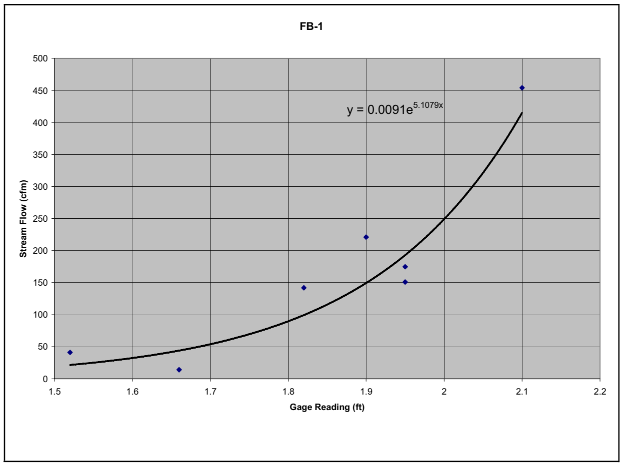


Figure 1 – Streamflow/Staff Gauge Correlation for FB-1

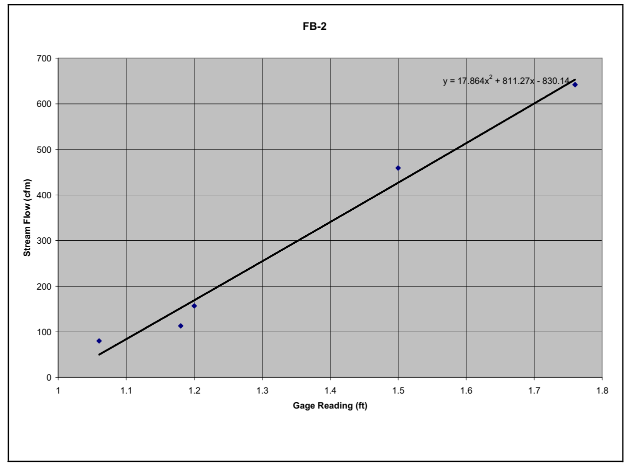


Figure 2 – Streamflow/Staff Gauge Correlation for FB-2

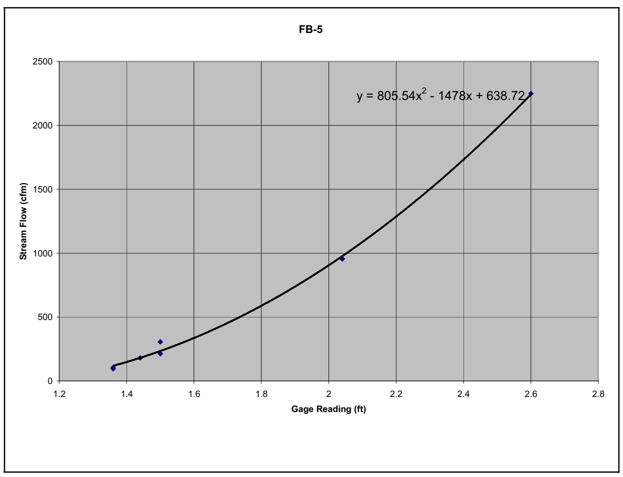


Figure 3 – Streamflow/Staff Gauge Correlation for FB-5

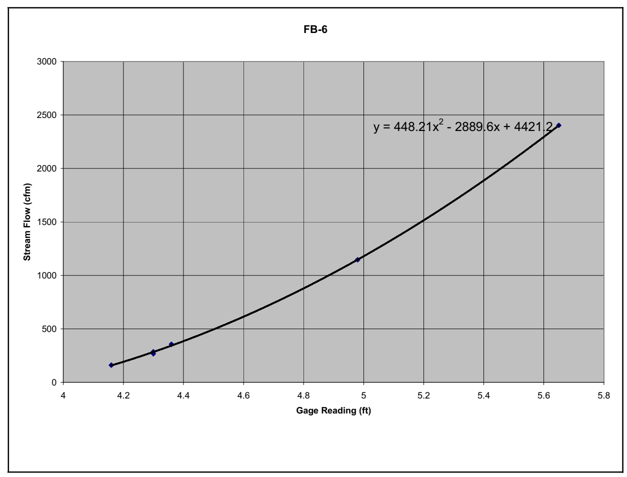


Figure 4 – Streamflow/Staff Gauge Correlation for FB-6

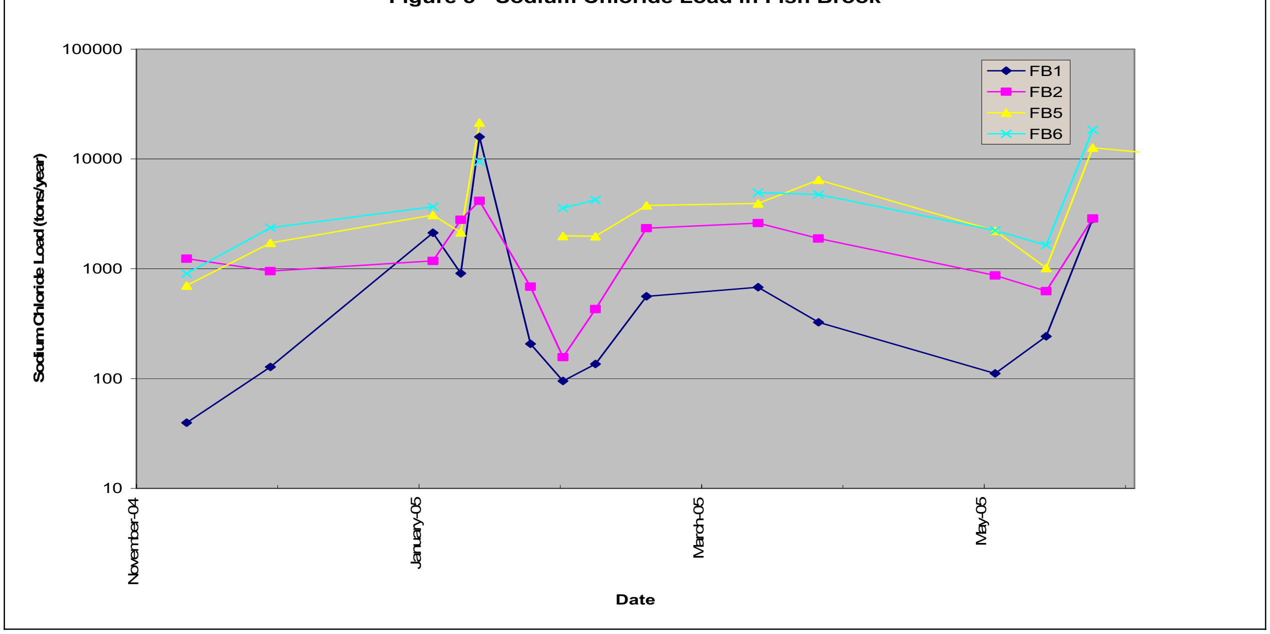


Figure 5 - Sodium Chloride Load in Fish Brook

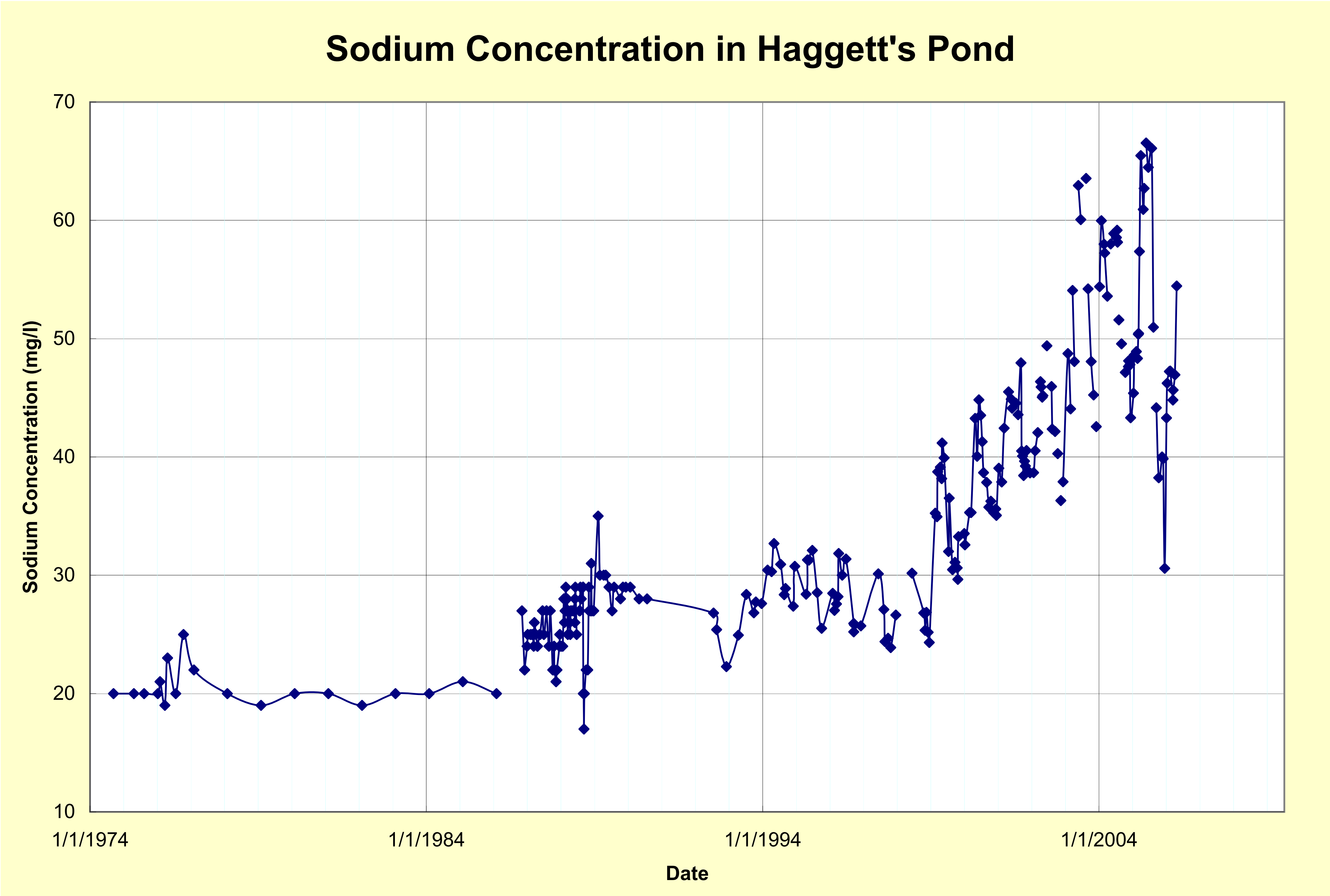
ANDOVER HISTORICAL SODIUM DATA

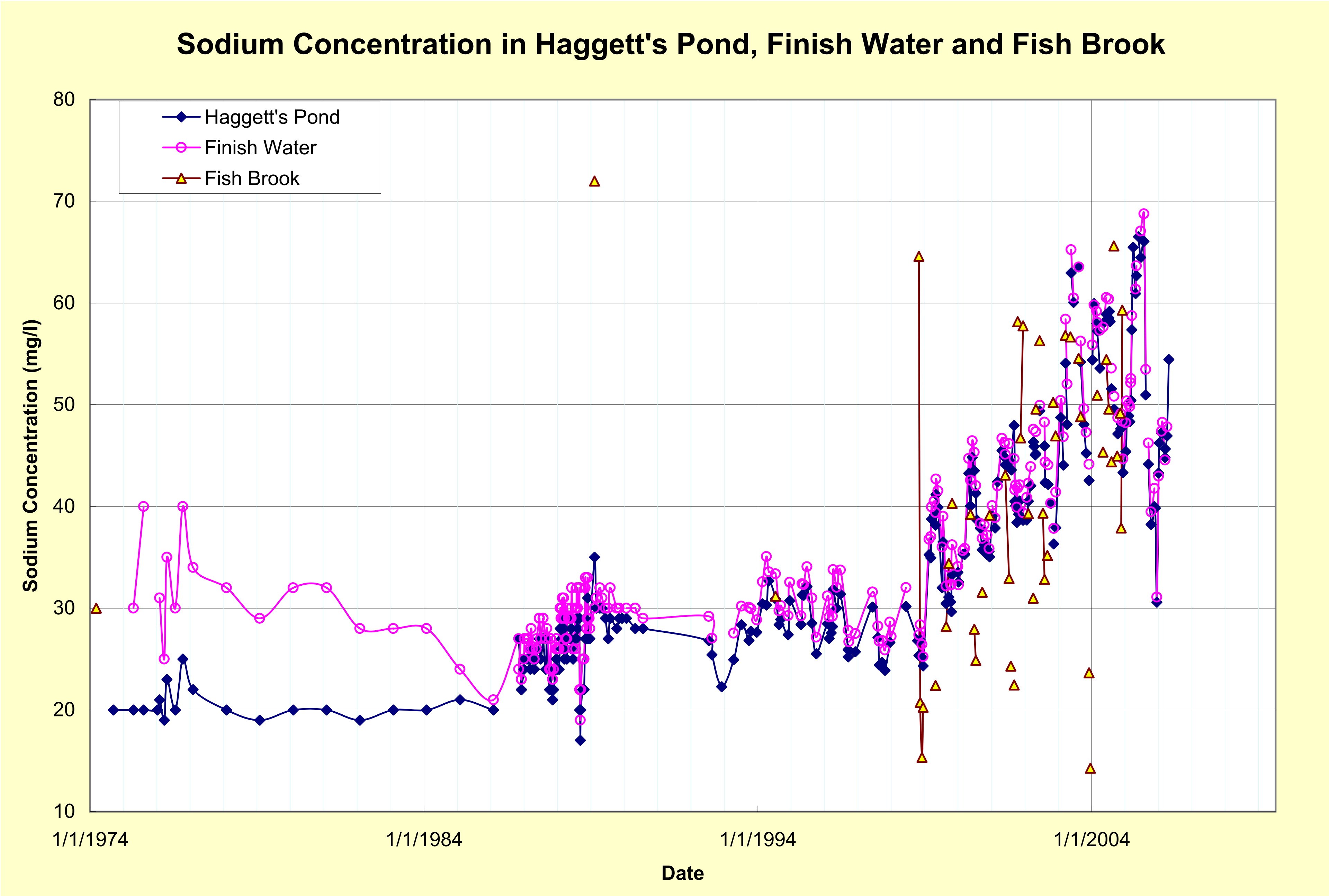
Date	Pond	Finish	Fishbrook	Merrimack River	Date	Pond	Finish	Fishbrook	Merrimack River
8/3/1970		17			6/17/1987	27	29		
1/25/1971		14			7/1/1987	25	27		
4/27/1971		20			7/29/1987	27	29		
2/2/1972		21			7/29/1987	27	29		
4/26/1972		25			8/26/1987	24	27		
1/9/1973		21			9/9/1987	27	28		
4/23/1973		20			10/6/1987	22	24		
3/11/1974			30		10/15/1987	22	24		
9/13/1974	20				10/19/1987	24	27		
4/22/1975	20	30			10/19/1987	24	27		
8/11/1975	20	40			10/23/1987	22	24		
1/8/1976	20				11/9/1987	21	23		
2/1/1976	21	31			11/9/1987	21	23		
3/23/1976	19	25			11/20/1987	22	24		
4/22/1976	23	35			12/16/1987	24	26		
7/21/1976	20	30			12/21/1987	25	27		
10/13/1976	25	40			12/21/1987	25	27		
2/1/1977	22	34			12/21/1987				
2/1/1978	20	32			1/1/1988	24	26		
2/1/1979	19	29			1/5/1988	24	26		
2/1/1980	20	32			1/20/1988	24	26		
2/1/1981	20	32			2/1/1988	28	30		
2/1/1982	19	28			2/6/1988	28	30		
2/1/1983	20	28			2/10/1988	26	29		
2/1/1984	20	28			2/16/1988	27	30		
2/1/1985	21	24			2/16/1988	27	30		
2/1/1986	20	21			2/24/1988	29	31		
11/5/1986		27			3/1/1988	27	29		
11/5/1986	27	24			3/10/1988	28	31		
12/4/1986	22	23			3/16/1988	25	26		
12/4/1986	22	23			3/23/1988	27	29		
12/31/1986	24	25			4/1/1988	26	27		
1/7/1987	25	27			4/5/1988	26	27		
1/7/1987	25	27			4/6/1988	26	27		
2/3/1987	25	27			4/13/1988	25	27		
2/20/1987	25	27			4/16/1988	27	30		
3/4/1987	25	26			5/1/1988	27	29		
3/4/1987	25	26			5/16/1988	27	29		
3/11/1987	24	26			5/16/1988	27	29		
3/19/1987	26	28			5/20/1988	27	29		
4/6/1987	25	26			6/1/1988	28	30		
4/22/1987	24	25			6/1/1988	26	29		
4/22/1987	24	25			6/6/1988	29	32		
5/15/1987	25	26			6/20/1988	25	26		
5/15/1987	25	26			7/18/1988		30		

5/20/1987	25	27			7/19/1988	27	30		
6/17/1987	27	29			7/20/1988		26		
7/26/1988	27	30			12/16/1994	30.75	32.56		
8/1/1988	29	32			4/18/1995	28.39	29.25		
8/10/1988	28	30			5/1/1995	31.3	32.4		
8/29/1988	29	32			5/18/1995	31.27	32.31		
8/29/1988	29	32			6/23/1995	32.11	34.07		
9/1/1988	20	22			8/15/1995	28.52	31		
9/5/1988	20	22			10/3/1995	25.52	27.15		
9/7/1988	17	19			2/1/1996	28.47	31.19		
9/13/1988	20	22			2/20/1996	27.03	29.14		
10/1/1988	22	25			3/13/1996	27.57	29.91		
10/18/1988	22	25			3/28/1996	28.2	29.2		
11/1/1988	29	32			4/5/1996	31.84	33.78		
11/2/1988	27	33			5/13/1996	30	32.04		
11/18/1988	27	28			6/24/1996	31.38	33.74		
11/22/1988	27	29			9/16/1996	25.93	27.83		
11/27/1988	31	33			9/17/1996	25.21			
12/1/1988	27	29			9/24/1996	25.82	26.7		
12/15/1988	27	29			12/3/1996	25.72	27.51		
12/22/1988	27	28			6/11/1997	30.12	31.6		
2/10/1989	35	30	72	28	8/8/1997	27.11	28.24		
3/1/1989	30	31			8/21/1997	24.4	26.76		
4/10/1989	30	32			9/23/1997	24.67	26.83		
5/3/1989	30	31			10/23/1997	23.88	25.89		
6/8/1989	29	30			12/16/1997	26.63	28.63		
7/10/1989	27	30			12/30/1997		27.21		
8/2/1989	29	32			6/11/1998	30.17	32.03		
10/10/1989	28	30			10/16/1998	26.8			
11/6/1989	29	30			10/30/1998	25.35	27.37	64.6	
12/7/1989	29				11/13/1998	26.87	28.37	20.72	
1/24/1990	29	30			12/2/1998	25.17	26.44	15.34	
5/1/1990	28	30			12/15/1998	24.32	25.23	20.25	
5/1/1990	28	30			2/18/1999	35.24	36.77		
7/26/1990	28	29			3/9/1999	34.94	37.04		
7/16/1992	26.8	29.2			3/17/1999	38.75	39.94		
8/18/1992	25.4	27.04			4/14/1999	39.14	40.52		
12/3/1992	22.27				4/29/1999	38.17	39.4	22.4	
4/12/1993	24.93	27.54			5/4/1999	41.18	42.69		
7/7/1993	28.38	30.2			5/26/1999	39.92	41.53		
9/27/1993	26.82	30.09			7/12/1999	32	36		
10/18/1993	27.74	29.96			7/20/1999	36.51	39.04		
12/20/1993	27.62	28.86			8/24/1999	30.47	32.19	28.19	
2/22/1994	30.43	32.6			9/21/1999	31.09	34.03	34.4	
4/7/1994	30.3	35.07			10/13/1999	30.62	32.27		
5/3/1994	32.69	33.58			10/21/1999	29.65	32.35		
7/15/1994	30.92	33.38	31.17		10/29/1999	33.26	36.22	40.3	
8/23/1994	28.36	29.74			12/30/1999	33.52	34.1		
9/7/1994	28.89	30.27			1/7/2000	32.57	32.28		

11/30/1994	27.39	29.27			2/25/2000	35.31	35.66		
3/14/2000	35.3	35.87			10/9/2002				33.71
4/26/2000	43.26	44.72			10/11/2002	40.28	40.33		
5/17/2000	40.06	42.58	39.2		11/6/2002			50.23	22.14
6/5/2000	44.82	46.46			11/14/2002	36.31	37.83		
6/26/2000	43.51	45.33	27.93		12/4/2002			46.93	40.46
7/13/2000	41.29	42.07	24.87		12/6/2002	37.91	41.41		
7/26/2000	38.67				1/29/2003	48.74	50.41		
8/30/2000	37.85	38.35			2/27/2003	44.06	46.85		
9/22/2000	35.76	36.87	31.57		3/20/2003			56.82	52.4
10/13/2000	36.25	38.19			3/21/2003	54.08	58.4		
11/14/2000	35.28	37.18			4/9/2003	48.06	52.02		
12/5/2000	35.6	35.85			5/14/2003			56.66	19.81
12/12/2000	35.06		39.14		5/21/2003	62.95	65.24		
1/8/2001	39.05	40.07			6/17/2003	60.06	60.5		
2/9/2001	37.88	38.89			8/13/2003			54.55	15.48
3/7/2001	42.44	42.02			8/14/2003	63.54	63.54		
4/25/2001	45.5	46.7			9/3/2003			48.84	26.73
5/23/2001	44.88	46.29			9/4/2003	54.21	56.25		
6/1/2001	44.11	45.12	43.08		10/9/2003	48.062	49.61		16.09
7/12/2001	44.54	46.18	32.92		11/3/2003	45.24	47.28		
7/18/2001				26.87	12/3/2003			23.65	15.19
8/1/2001			24.3	29.41	12/4/2003	42.57	44.16		
8/6/2001	43.58				12/19/2003			14.27	
9/6/2001	47.96	44.7	22.46	31.39	1/9/2004	54.4	55.89		
9/13/2001	40.51	41.64			1/28/2004	59.96	59.81		
9/24/2001	40.07	42.1			2/24/2004	57.99	59.19		
10/4/2001	38.42	39.93			3/4/2004	57.24	58.1	50.95	
10/15/2001	39.64	41.79	58.17	26.83	4/2/2004	53.59	57.31		
10/24/2001	39.24				5/5/2004			45.35	23.52
11/5/2001	40.54	42.13			5/7/2004	58.01	57.63		
11/15/2001			46.74	22.19	6/9/2004	58.89	60.55	54.45	52.83
12/13/2001	38.65	39.38	57.75	22.46	7/7/2004			49.58	27.83
1/22/2002	38.67	40.88		44.65	7/8/2004	58.54	60.38		
2/8/2002	40.52	42.28	39.3	47.22	7/15/2004	59.16			
3/7/2002	42.05	43.92		49.57	7/21/2004	58.16			
4/3/2002			30.98	21.52	8/4/2004			44.38	20.53
4/5/2002	46.36	47.59			8/5/2004	51.58	53.6		
4/12/2002	45.92				9/1/2004			65.61	20.2
4/25/2002	45.06				9/2/2004	49.57	50.84		
5/1/2002			49.58	26.52	10/6/2004			44.96	21.01
5/2/2002	45.18	47.34			10/14/2004	47.14	48.73		
6/12/2002			56.3	40.37	11/10/2004			49.18	18.89
6/14/2002	49.4	49.95			11/15/2004	47.64	49.11		
7/17/2002			39.35	20.88	11/19/2004	48.12		37.89	
8/5/2002	45.95	48.29	32.83	27.97	12/1/2004			59.31	56.28
8/12/2002	42.35	44.37			12/2/2004	47.8	48.37		
9/4/2002			35.18	34.61	12/9/2004	43.32	44.68		
9/11/2002	42.16	44.08			1/10/2005	45.39	48.22	88	

1/18/2005	48.6	50.37	94						
1/31/2005			65						
2/3/2005			115						
2/9/2005	48.91	50.06	137						
2/23/2005	48.33	49.81	99.6						
3/3/2005	50.37	52.16							
3/7/2005	50.45	52.57	181						
3/17/2005	57.37	58.75	203						
3/30/2005	65.48		99						
4/26/2005	60.93	61.37							
5/6/2005	62.7	63.66	103						
5/17/2005			114						
5/27/2005	66.53		114						
6/21/2005	64.48	67.08	77.21	22.94					
7/27/2005	66.08	68.77	79.64	30.6					
8/15/2005	50.96	53.47	40.92	23.58					
9/7/2005			17.49	12.86					
9/14/2005	44.16	46.24							
10/12/2005	38.24	39.47	23.04	20.45					
11/17/2005	40	41.77							
11/28/2005	39.85								
12/15/2005	30.59	31.09							
1/4/2006	43.29	42.97	85	20.83					
1/11/2006	46.24		111						
2/3/2006	47.22	47.4							
2/14/2006	47.27	48.26							
3/14/2006	44.81	44.56							
3/16/2006	45.66		87.2	26.57					
4/5/2006	46.94	47.82	99.8	29.59					
4/24/2006	54.45								


Sodium Concentration in Haggett's Pond
Sodium Concentration (mg/l)
70
60
50
40
30
20
10
1/1/1974
1/1/1984
1/1/1994
1/1/2004
Date


Sodium Concentration in Haggett's Pond, Finish Water and Fish Brook
Haggett's Pond
Finish Water
Fish Brook
Sodium Concentration (mg/l)
80
70
60
50
40
30
20
10
1/1/1974
1/1/1984
1/1/1994
1/1/2004
Date

			Sampler						mg/l	mg/l	umhos/cm	mg/l		100 ml	
Location	Date	Time	init.	pH	T, cent.	Color	NTU	DO, mg/l	Sodium	Chlorides	Cond.	Calcium	Total	Fecal Col.	E.Coli
FB4, River Rd Culvert	4/2/2004	730	EP	6.53	8.6	45	3.4		25.8	56	208		1720	370	340
FB3	4/2/2004	1130	CV	7.04	9.2	50	6.5		18.4	40	320				
FB3b	4/2/2004	1130	CV	6.82	8.7	>50	30		67.3	134	686				
FB1	5/6/2004		CV/EP	6.62	17.4	56	0.50		40.1	82	653		3200	140	30
FB2	5/6/2004		CV/EP	6.31	13.1	>60	0.56	5.6	95.3	174	312		1100	60	40
FB3	5/6/2004		CV/EP	6.46	15.4	55	0.35	7.6	49.2	88	634		1500	180	60
FB4	5/6/2004		CV/EP	7.18	15.2	>60	7.00	7.2	26.2	54	700		1700	120	80
FB5	5/6/2004	1030	JZ	6.93	16	>60	8.20	6.0	96.6	180	487		400	40	<20
FB6	5/6/2004		CV/EP	7.40	14.9	52	0.62	9.3	89	180	619		300	20	20
									Na, mg/l	Chl, mg/l	Cond.	Ca, mg/l			
FB1	11/12/2004								49.1	100	450	9.5			
FB2	11/12/2004								79.1	164	600	8.7			
FB5	11/12/2004								93.4	206	750	19			
FB6	11/12/2004								75.8	184	660	16.2			
Fishbrook from students	10/14/2004								104	208	750	14.1			
Rafton Reservation stream	11/12/2004								30.5	80	350	5.2			
									Na, mg/l						
Windemere #5	11/18/04		Brady						54						
WR & Hemlock #2	11/18/04		Brady						25						
RT 133 #4	11/18/04		Brady						144						
NOC 495 #8	11/18/04		Brady						94						
Pondview #3	11/18/04		Brady						30						
Powerline #9	11/18/04		Brady						37						
Barrons, #6	11/18/04		Brady						38						
Indian Ridge #1	11/18/04		Brady						41						
RR Grade @ HAG #7	11/18/04		Brady						42						
									Na, mg/l						
Saltshed 93, #1	11/30/2004		Brady						969						
Saltshed 93, #2	11/30/2004		Brady						173						
FB1	11/30/2004		Brady						63						
FB2	11/30/2004		Brady						67						
FB5	11/30/2004		Brady						70						
FB6	11/30/2004		Brady						70						
WHMS	11/30/2004		Brady						85						
									Na, mg/l						
93 - NO	12/9/2004		CV						544						
93 - SO	12/9/2004		CV						1233						

495 - NR	12/9/2004		CV						195						
495 - SO1	12/9/2004		CV						497						
495-SO2	12/9/2004		CV						4223						
495-SO3	12/9/2004		CV						519						

		Date							Na, mg/l						
FB1		1/4/2005	TB						123						
FB2		1/4/2005	TB						98						
FB5		1/4/2005	TB						96						
FB6		1/4/2005	TB						88						
Culvert on Starwood Crossing		1/5/2005	TB						59						
Wood Hill Bridge		1/6/2005	TB						108						
Wood Hill School Bridge		1/5/2005	TB						128						
NW Quad 93 & 495 Clover Leaf		1/5/2005	TB						517						
Under High Plain Culvert from salt shed & CL		1/4/2005	TB						730						
93 NW Quad		1/6/2005	TB						7,180						
High Plain Culvert		1/6/2005	TB						14,612						

									Na, mg/l						
FB1		1/10/2005	TB						330						
FB2		1/10/2005	TB						130						
FB5		1/10/2005	TB						113						
Wood Hill Bridge		1/10/2005	TB						157						
Under High Plain Culvert		1/10/2005	TB						2,262						
NW Quad 93 & 495		1/10/2005	TB						991						

									Na, mg/l						
FB1		1/14/2005	TB						97						
FB2		1/14/2005	TB						166						
FB5		1/14/2005	TB						143						
FB6		1/14/2005	TB						94						
Wood Hill Bridge		1/14/2005	TB						180						
NW Quad 93 & 495		1/14/2005	TB						605						
Under High Plain Culvert from salt shed & CL		1/14/2005	TB						761						

									Na, mg/l						
FB1		1/25/2005	TB						43						
FB2		1/25/2005	TB						130						
FB5		1/25/2005	TB						141						
FB6		1/25/2005	TB						65						
NW Quad 93 & 495		1/25/2005	TB						684						
Culvert under High Plain		1/25/2005	TB						1,125						

Na, mg/l

FB1		2/1/2005	TB						52						
FB2		2/1/2005	TB						114						
FB5		2/1/2005	TB						118						
FB6		2/1/2005	TB						115						
NW Quad 93 & 495		2/1/2005	TB						712						
Culvert under High Plain		2/1/2005	TB						1,699						
Fishbrook - WH site		1/13/2005							226						
WH control site		1/13/2005							24						

FB1		2/8/2005	TB						67						
FB2		2/8/2005	TB						206						
FB5		2/8/2005	TB						151						
FB6		2/8/2005	TB						137						
NW Quad 93 & 495		2/8/2005	TB						857						
Culvert under High Plain		2/8/2005	TB						2,203						
Wood Hill School Bridge		2/8/2005	TB						223						

FB1		2/19/2005	TB						100						
FB2		2/19/2005	TB						117						
FB5		2/19/2005	TB						100						
FB6		2/19/2005	TB						100						
NW Quad 93 & 495		2/19/2005	TB						680						
Culvert under High Plain		2/19/2005	TB						966						
Wood Hill School Bridge		2/19/2005	TB						100						
FB3		2/19/2005	TB						99						
FB under 93		2/19/2005	TB						84						
TAP (glass bottle)			TB						50						
FB6 (glass bottle)			TB						93						
FB3 (glass bottle)			TB						75						

FB1		3/15/2005	TB						247						
FB2		3/15/2005	TB						216						
FB5		3/15/2005	TB						197						
FB6		3/15/2005	TB						171						
NW Quad 93 & 495		3/15/2005	TB						1137						
Culvert under High Plain		3/15/2005	TB						2,210						
Wood Hill School Bridge		3/15/2005	TB						311						
495 stream west of FB, cross of 495		3/15/2005	TB						1,047						
Starwood Xing		3/15/2005	TB						58						

FB1		3/28/2005	TB						71						
FB2		3/28/2005	TB						98						
FB5		3/28/2005	TB						201						
FB6		3/28/2005	TB						99						
NW Quad 93 & 495		3/28/2005	TB						977						
Culvert under High Plain		3/28/2005	TB						2,265						
Wood Hill School Bridge		3/28/2005	TB						124						
495 stream west of FB, cross of 495		3/28/2005	TB						461						

FB1		5/5/2005	TB						61						
FB2		5/5/2005	TB						112						
FB5		5/5/2005	TB						158						
FB6		5/5/2005	TB						103						
NW Quad 93 & 495		5/5/2005	TB						763						
Culvert under High Plain		5/5/2005	TB						1,011						
Wood Hill School Bridge		5/5/2005	TB						120						
FB3 on W side of 93		5/5/2005	TB						121						
Parallel to 495 W nr HP bridge		5/5/2005	TB						370						

FB1		5/16/2005	TB						65						
FB2		5/16/2005	TB						111						
FB3		5/16/2005	TB						121						
FB5		5/16/2005	TB						113						
FB6		5/16/2005	TB						114						
NW Quad 93 & 495		5/16/2005	TB						627						
Culvert under High Plain		5/16/2005	TB						567						
Wood Hill School Bridge		5/16/2005	TB						126						
Stream parallel to 495		5/16/2005	TB						281						

FB1		5/26/2005	TB						32						
FB2		5/26/2005	TB						54						
FB3		5/26/2005	TB						54						
FB5		5/26/2005	TB						80						
FB6		5/26/2005	TB						114						
NW Quad 93 & 495		5/26/2005	TB						276						
Culvert under High Plain		5/26/2005	TB						210						
Wood Hill School Bridge		5/26/2005	TB						87						

Stream parallel to 495		5/26/2005	TB						112						

									mg/l Na		Arsenic, mg/l				
FB1		1/10/2006	TB						137		0.001				
FB2		1/10/2006	TB						105		0.002				
FB3		1/10/2006	TB						93		0.017	Digested sample (muddy/sandy),			70 mg/l
FB5		1/10/2006	TB						113		<0.001				
FB6		1/10/2006	TB						111		0.001				
NW Quad 93 & 495		1/10/2006	TB						740		0.001				
Culvert under High Plain		1/10/2006	TB						1,120		<0.001				
Wood Hill School Bridge		1/10/2006	TB						130		<0.001				
93 West Side		1/10/2006	TB						113		0.002	Digested sample (muddy/sandy),			8.3 mg/l

									mg/l Na
FB1		3/15/2006	TB						53
FB2		3/15/2006	TB						97
Wood Hill Bridge		3/15/2006	TB						103
FB5		3/15/2006	TB						92
FB6		3/15/2006	TB						85
NW Quad 93 & 495		3/15/2006	TB						500
Culvert under High Plain		3/15/2006	TB						1,213

									mg/l Na		Arsenic, mg/l		
FB1		3/31/2006	TB						49		0.002		
FB2		3/31/2006	TB						108		0.004		
Wood Hill Bridge		3/31/2006	TB						116		<0.001		
FB5		3/31/2006	TB						101		0.002		
FB6		3/31/2006	TB						73		0.004		
NW Quad 93 & 495		3/31/2006	TB						751		0.001		
Culvert under High Plain		3/31/2006	TB						836		0.003		
(muddy sample)		3/31/2006	TB								4.6 mg/l	not fully digested	

Water Quality Analysis, 2000

	February, 2000		March, 2000		April, 2000		May, 2000		June, 2000		July, 2000		August, 2000	
	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish
Sodium, mg/l	35.31	35.66	35.15	35.87	43	44.72	40.06	42.58	44.89	46.46	41.29	42.07	37.85	38.35
Calcium, mg/l	10.68	10.45	9.9	9.83	10.58	9.86	9.9	10.1	11.19	10.69	10.6	10.15	10.56	10.26
Chlorides, mg/l	71	72	69	69	80	81	78	80	83	87	78	80	76	78
Specific conductance, umhos/cm	320	380	325	380	350	375	350	400	350	400	350	400	325	400
											Fbrook 24.87 mg/l Na			

	September, 2000		Oct., 2000		Nov., 2000		Dec., 2000	
	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish
Sodium, mg/l	35.76	36.87	36.25	38.19	35.28	37.18	35.6	35.9
Calcium, mg/l	9.87	9.19	9.96	9.81	10.94	11.25	12.37	11.83
Chlorides, mg/l	70	72	65	67.5	70	72	72.5	73
Specific conductance, umhos/cm	300	350	300	350	300	350	300	360
	Fishbrook 31.57 mg/l Na							

METHODS

Sodium, Standard Methods 18th Ed., 3111B

Calcium, Standard Methods 18th Ed., 3111B

Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0

Specific Conductance, Standard Methods 18th Ed., 2510B

Alan Carifio

Water Quality Analysis, 2001

Andover Water Plant
Andover, Mass.

Sodium, Standard Methods 18th Ed., 3111B
Calcium, Standard Methods 18th Ed., 3111B
Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0
Specific Conductance, Standard Methods 18th Ed., 2510B

	January, 2001		February, 2001		March, 2001		April, 2001		May, 2001	
	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish	Raw	Finish
Sodium, mg/l	39.05	40.07	37.88	38.9	41.88	42.02	45.5	46.7	44.4	46.3
Calcium, mg/l	11.6	11.2	11.8	11.7	11.23	10.27	9.0	8.22	11.3	10.3
Chlorides, mg/l	76.5	80	78.5	80.5	82	84	87	90	82	85
Specific conductance, umhos/cm	350	400	350	400	350	450	350	450	350	400

	June, 2001			July, 2001			Merrimack River
	Raw	Finish	Fishbrook	Raw	Finish	Fishbrook	
Sodium, mg/l	44.1	45.1	172	44.5 (on 12th)	46.2 (on 12th)	98.8 (3rd)	26.9 (on 18th)
Calcium, mg/l	10.82	9.87	25	10.89 (on 12th)	9.85 (on 12th)	15.73 (3rd)	6.8 (on 18th)
Chlorides, mg/l	88	88	245	82 (on 12th)	82, (on 12th)	172 (3rd)	
Specific conductance, umhos/cm	410	550	825	350 (on 11th)	400 (on 11th)	700 (3rd)	

	August, 2001				September, 2001			
	Raw	Finish	Fishbrook	Merrimack River	Raw	Finish	Fishbrook	Merrimack River
Sodium, mg/l	43.6 (on 6th)	44. 4 (on 6th)	97.2 (on 1st)	29.4 (on 1st)	47.9 (on 6th)	44.7 (on 6th)	135 (on 5th)	31.3 (on 5th)
Calcium, mg/l	10.12 (on 6th)	9.40 (on 6th)	28.3 (on 1st)	8.5 (on 1st)	9.52 (on 6th)	8.9 (on 6th)	29.3 (on 5th)	9.29 (on 5th)
Chlorides, mg/l	80 (on 6th)	80, (on 6th)	184 (on 1st)	50 (on 1st)	75 (on 6th)	71 (on 6th)	297 (on 5th)	56 (on 5th)
Specific conductance, umhos/cm	350 (on 6th)	400 (on 6th)	750 (on 1st)	250 (on 1st)	310 (on 7th)	350 (on 7th)	900 (on 5th)	275 (on 5th)
Iron				0.074 mg/l (15th)			ND	ND
Manganese							ND	ND

	October, 2001				November, 2001			
	Raw	Finish	Fishbrook	Merrimack River	Raw	Finish	Fishbrook	Merrimack River
Sodium, mg/l	38.4 (on 4th)	39.9 (on 4th)	233 (on 10th)	27 (on 10th)	40.5 (on 5th)	42.1 (on 5th)	140 (on 14th)	22 (on 14th)
Calcium, mg/l	10.5 (on 15th)	9.0 (on 15th)	33 (on 10th)	9.2 (on 10th)	10.2 (on 5th)	9.3 (on 5th)	38 (on 14th)	6.7 (on 14th)
Chlorides, mg/l	70 (on 3rd)	70 (on 3rd)	167 (on 10th)	45 (on 10th)	70 (on 15th)	75 (on 15th)	240 (on 14th)	37.5(on 14th)
Specific conductance, umhos/cm	310 (on 3rd)	350 (on 3rd)	750 (on 10th)	250 (on 10th)	300 (on 5th)	360 (on 5th)	900 (on 14th)	200 (on 14th)
Iron, mg/l					ND	ND	ND	0.16 (14th)
Manganese, mg/l								
Aluminum, mg/l							0.03 (on 14th)	0.088 (on 14th)

	December, 2001			
	Raw	Finish	Fishbrook	Merrimack River
Sodium, mg/l	38.7 (on 13th)	39.3 (on 13th)	173 (on 12th)	22.5 (on 12th)
Calcium, mg/l	10.5 (on 13th)	10.2 (on 13th)	39.3 (on 12th)	6.4 (on 12th)
Chlorides, mg/l	70 (on 6th)	72 (on 6th)	275 (on 12th)	40 (on 12th)
Specific conductance, umhos/cm	300 (on 6th)	350 (on 6th)	1000 (on 12th)	225 (on 12th)
Iron, mg/l	ND	ND	ND	0.150
Manganese, mg/l	ND	ND	ND	0.063
Aluminum, mg/l				

Water Quality Analysis, 2002

Andover Water Plant
Andover, Mass.

Sodium, Standard Methods 18th Ed., 3111B
Calcium, Standard Methods 18th Ed., 3111B
Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0
Specific Conductance, Standard Methods 18th Ed., 2510B

	January, 2002				February, 2002			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	38.7 (22nd)	40.9 (22nd)		44.7 (9th)	40.4 (8th)	42.3 (8th)	236 (6th)	47.2 (6th)
			OFF					
Calcium, mg/l	11.5 (23rd)	11.4 (23rd)		8.7 (9th)	12.3 (8th)	11.9 (8th)	41.7 (6th)	8.7 (6th)
Chlorides, mg/l	70 (16th)	70 (16th)		78 (9th)	83 (8th)	82 (8th)	437 (6th)	84 (8th)
Specific								
conductance,	300 (10th)	350 (10th)		350 (9th)	325 (7th)	375 (7th)	1600 (6th)	375 (6th)
umhos/cm								
Ammonia Nitrogen, mg/l					0.04 (8th)		0.30 (6th)	0.50 (6th)

	March, 2002				April, 2002			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	42.1 (on 7th)	43.7 (on 7th)		248 (on 6th)	46.4 (on 5th)	47.6 (on 5th)	155 (on 3rd)	21.5 (on 3rd)
Calcium, mg/l	12.7 (on 7th)	12.4 (on 7th)		23.7 (on 6th)	13.3 (on 5th)	13.3 (on 5th)	25.2 (on 3rd)	5 (on 5th)
Chlorides, mg/l	80 (on 8th)	81 (on 8th)		240 (on 6th)	94 (on 5th)	96 (on 5th)	270 (on 3rd)	47 (on 3rd)
			OFF					
Specific								
conductance,	350 (on 5th)	400 (on 5th)		850 (on 6th)	360 (on 5th)	400 (on 5th)	950 (on 3rd)	200 (on 3rd)
umhos/cm								
Iron, mg/l	ND	ND		0.10				
Ammonia Nitrogen, mg/l	0.05 (on 6th)			1.3 (on 6th)				

	May, 2002				June, 2002			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	45.3 (on 2nd)	47.3 (on 32nd	496 (on 1st)	26.5 (on 1st)	49 (on 17th)	50 (on 17th)	56 (on 12th)	80.7 (on 12th)
Calcium, mg/l	13.4 (on 13th)	12.6 (on 13th)	23.2 (on 1st)	8.13 (on 1st)	14.9 (on 17th)	14.7 (on 17th)	16.8 (on 12th)	20.0 (on 12th)
Chlorides, mg/l	97 (on 13th)	98 (on 13th)	210 (on 1st)	57 (on 1st)	98 (on 17th)	100 (on 17th)	115 (on 17th)	142 (on 12th)
Specific	375 (on 6th)	400 (on 6th)	750 (on 1st)	250 (on 1st)	400 (on 17th)	425 (on 17th)	450 (on 12th)	525 (on 12th)
conductance,								
umhos/cm								
Iron, mg/l	ND	ND	0.185 (on 1st)	0.235 9on 1st)				
Manganese, mg/l	ND	ND	ND	0.020 (on 1st)				

	July, 2002				August, 2002			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l			39.3 (on 17th)	20.9 (on 17th)	42.4 (on 12th)	45 (on 12th)	32.8 (on 12th)	27.9 (on 12th)
Calcium, mg/l			11 (on 17th)	5 (on 17th)	10.5 (on 12th)	10 (on 12th)	9.8 (on 5th)	7.1 (on 5th)
Chlorides, mg/l			90 (on 17th)	110 (on 17th)	94 (on 12th)	92 (on 12th)	68 (on 5th)	64 (on 5th)
Specific								
conductance,	400 (on 9th)	425 (on 9th)	325 (on 9th)	200 (on 9th)	350 (on 12th)	400 (on 12th)	300 (on 5th)	250 (on 5th)
umhos/cm								
Iron, mg/l			0.168	0.05	ND (on 1st)			
Manganese, mg/l			0.038	ND				

	September, 2002				October, 2002			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	42.2 (on 11th)	44.1 (on 11th)	35.2 (on 4th)	34.6 (on 4th)	39.9 (on 11th)	40.3 (on 11th)	off	33.7 (on 9th)
Calcium, mg/l	11.5 (on 11th)	11.3 (on 11th)	8.5 (on 4th)	9.0 (on 4th)	7.9 (on 11th)	6.5 (on 11th)	off	23 (on 9th)
Chlorides, mg/l	82 (on 9th)	82 (on 9th)	62 (on 4th0	62 (on 4th)	82 (on 10th)	82 (on 10th)	off	70 (on 9th)
Specific	310 (on 9th)	350 (on 9th)	250 (on 4th)	250 (on 4th)	325 (on 11th)	375 (on 11th)	off	350 (on 9th)
conductance,								
umhos/cm								
								TOC = 5.332 mg/l

	November, 2002				December, 2002			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	36.2 (on 14th)	37.8 (on 14th)	50.2 (on 6th)	22.1 (on 14th)	37.9 (on 6th)	41.4 (on 6th)	187 (on 6th)	40.5 (on 6th)
Calcium, mg/l	9.99 (on 14th)	9.91 (on 14th)	16 (on 6th)	8 (on 6th)	10.3 (on 6th)	10.1 (on 6th)	17.6 (on 4th)	7.7 (on 4th)
Chlorides, mg/l	80 (on 13th)	86 (on 13th)	104 (on 6th)	50 (on 6th)	94 (on 6th)	94 (on 6th)	210 (on 4th)	80 (on 4th)
Specific	310 (on 13th)	360 (on 13th)	400 (on 6th)	225 (on 6th)	325 (on 2nd)	375 (on 2nd)	750 (on 4th)	325 (on 4th)
conductance,								
umhos/cm								

Water Quality Analysis, 2003

Sodium, Standard Methods 18th Ed., 3111B
Calcium, Standard Methods 18th Ed., 3111B
Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0
Specific Conductance, Standard Methods 18th Ed., 2510B

Andover Water Plant
Andover, Mass.

	January, 2003				February, 2003			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	48.7 (on 29th)	50.4 (on 29th)			44.4 (on 27th)	46.9 (on 27th)		
Calcium, mg/l	11.6 (on 29th)	10.8 (on 29th)			13.4 (on 27th)	11.7 (on 27th)		
Chlorides, mg/l	108 (on 28th)	108 (on 28th)	OFF	FROZEN	110 (on 26th)	112 (on 26th)	OFF	FROZEN
Specific								
conductance,	375 (on 6th)	440 (on 6th)			410 (on 26th)	450 (on 26th)		
umhos/cm								

	March, 2003				April, 2003			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	54.1 (on 20th)	57.8 (on 20th)	113.6 (on 19th)	104.8 (on 19th)	48.1 (on 9th)	52.02 (on 9th)		
Calcium, mg/l	13.6 (on 20th)	13.6 (on 20th)	14.4 (on 19th)	14.4 (on 19th)	12.7 (on 30th)	12.8 (on 30th)		
Chlorides, mg/l	120 (on 20th)	122 (on 20th)	190 (on 19th)	192 (on 19th)	112 (on 30th)	114 (on 30th)	OFF	OFF
Specific								
conductance,	440 (on 20th)	490 (on 20th)	650 (on 19th)	650 (on 19th)	400 (on 8th)	450 (on 8th)		
umhos/cm								
Iron, mg/l								

	May, 2003				June, 2003			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	63.2 (5/21)	65.2 (5/21)	113 (5/14)	19.8 (5/14)	60.1 (6/17)	60.4 (6/17)		
Calcium, mg/l	13.2 (5/21)	12.1 (5/21)	22.8 (5/14)	4.9 (5/14)	13.6 (6/17)	12.3 (6/17)		
							OFF	
Chlorides, mg/l	126 (on 20th)	126 (on 20th)	192 (on 14th)	40 (on 14th)	130 (6/17)	118 (6/17)		
Specific								
conductance,	425 (on 7th)	450 (on 7th)	750 (on 7th)	200 (on 7th)	453 (6/17)	490 (6/17)		
umhos/cm								

	July, 2003				August, 2003			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l					56.8 (8/14)	63.5 (8/14)	164 (8/13)	15.5 (8/13)
Calcium, mg/l					12.8 (8/14)	13.1 (8/14)	22.9 (8/13)	2.7 (8/13)
Chlorides, mg/l	AC / VACATION &		OFF		114 (8/14)	118 (8/14)	204 (8/13)	33 (8/13)
	LAB AUDIT							
Specific								
conductance,					425 (8/13)	486 (8/13)	750 (8/13)	120 (8/13)
umhos/cm								

	September, 2003				October, 2003			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	54.2 (9/8)	56.2 (9/8)	147 (9/3)	26.7 (9/3)	48.6 (10/09)	49.6 (10/09)	49 (10/01)	16.1 (10/01)
Calcium, mg/l	15.3 (9/8)	14.1 (9/8)	19.9 (9/3)	9.6 (9/3)	13.3 (10/09)	12.8 (10/09)	11 (10/01)	4.6 (10/01)
Chlorides, mg/l	108 (9/8)	108 (9/8)	254 (9/3)	60 (9/3)	98 (10/08)	102 (10/08)	100 (10/01)	30 (10/01)
Specific								
conductance,	420 (9/3)	455 (9/3)	890 (9/3)	235 (9/3)	378 (10/06)	428 (10/06)	376 (10/01)	143 (10/01)
umhos/cm								

	November, 2003				December, 2003			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	45.2 (11/13)	47.3 (11/13)			42.6 (12/04)	44.2 (12/04)	118.3 (12/03)	15.2 (12/04)
Calcium, mg/l	13.99 (11/28)	13.5 (11/28)			12.1 (12/04)	11.5 (12/04)	17.2 (12/03)	2.0 (12/03)
Chlorides, mg/l	102 (11/24)	102 (11/24)	OFF		99 (12/04)	106 (12/04)	230 (12/03)	32 (12/04)
Specific								
conductance,	313 (11/12)	361 (11/12)			311 (12/1)	342 (12/1)	680 (12/03)	121 (12/03)
umhos/cm								

Water Quality Analysis, 2004

Andover Water Plant
Andover, Mass.

Sodium, Standard Methods 18th Ed., 3111B
Calcium, Standard Methods 18th Ed., 3111B
Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0
Specific Conductance, Standard Methods 18th Ed., 2510B

	January, 2004				February, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	54 (1/09)	56 (1/09)			58 (2/24)	59 (2/24)		
lbs/gal sodium	0.00045	0.000467292						
Calcium, mg/l	13.8 (1/28)	13 (1/28)			14.7 (2/24)	14.2 (2/24)		
Chlorides, mg/l	108 (1/28)	112 (1/28)			116 (2/24)	120 (2/24)		
			OFF	**FROZEN**			OFF	
Specific								
conductance,	420 (1/28)	470 (1/28)			440 (2/13)	480 (2/13)		
umhos/cm								

	March, 2004				April, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	57.2 (3/4)	58.1 (3/4)	102 (3/3)	27.5 (3/3)	53.6 (4/2)	57.3 (4/02)		
Calcium, mg/l	13.5 (3/4)	12.7 (3/4)	19.8 (3/3)	7.9 (3/3)	14.7 (4/23)	14 (4/23)		
							OFF	
Chlorides, mg/l	118 (3/5)	125 (3/5)	208 (3/3)	56 (3/3)	120 (4/5)	128 (4/5)		
Specific								
conductance,	443 (3/3)	480 (3/3)	838 (3/3)	270 (3/3)	440 (4/2)	489 (4/2)		
umhos/cm								

	May, 2004				June, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	58 (5/7)	58 (5/7)	91 (5/5)	23.5 (5/5)	58.9 (6/9)	60.6 (6/9)	54.5 (6/9)	52.8 (6/9)
Calcium, mg/l	13.8 (5/12)	12.7 (5/12)	18 (5/5)	6.3 (5/5)	14.3 (6/9)	13.2 (6/9)	12.5 (6/9)	12.4 (6/9)
Chlorides, mg/l	116 (5/7)	114 (5/7)	160 (5/5)	52 (5/5)	124 (6/9)	120 (6/9)	112 (6/9)	100 (6/9)
Specific								
conductance,	408 (5/5)	434 (5/5)	590 (5/5)	182 (5/5)	400 (6/9)	450 (6/9)	390 (6/9)	387 (6/9)
umhos/cm								

	July, 2004				August, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	58.5 (7/8)	60.4 (7/7)	49.6 (7/7)	27.8 (7/7)	51.6 (8/5)	53.6 (8/5)	44.4 (8/4)	20.5 (8/5)
Calcium, mg/l	14.7 (7/8)	13.1 (7/8)	14.2 (7/7)	7.1 (7/7)	12 (8/5)	10.3 (8/5)	11 (8/4)	5.3 (8/4)
Chlorides, mg/l	114 (7/1)	114 (7/1)	94 (7/7)	50 (7/7)	100 (8/5)	100 (8/5)	84 (8/4)	40 (8/4)
Specific								
conductance,	410 (7/1)	470 (7/1)	370 (7/7)	227 (7/7)	400 (8/2)	450 (8/2)	350 (8/4)	200 (8/4)
umhos/cm								

	September, 2004				October, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	49.6 (9/2)	51.4 (9/2)	65.6 (9/1)	20.2 (9/1)	47.1 (10/14)	48.7 (10/14)	90 (10/6)	21 (10/6)
Calcium, mg/l	11.5 (9/13)	10.6 (9/13)	12.8 (9/13)	6.1 (9/13)	12.3 (10/14)	11.8 (10/14)	15.7 (10/6)	7.3 (10/6)
Chlorides, mg/l	98 (9/7)	100 (9/7)	122 (9/1)	42 (9/1)	100 (10/7)	100 (10/7)	156 (10/6)	48 (10/6)
Specific								
conductance,	370 (9/2)	440 (9/2)	515 (9/1)	186 (9/1)	350 (10/7)	410 (10/7)	550 (10/6)	200 (10/6)
umhos/cm								

	November, 2004				December, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	47.6 (11/15)	49.1 (11/15)	98.4 (11/10)	18.9 (11/10)	47.8 (12/2)	48.4 (12/2)	59.3 (12/1)	56.3 (12/1)
Calcium, mg/l	12.3 (11/15)	11.1 (11/15)	17.0 (11/10)	5.5 (11/10)	12.3 (12/03)	10 (12/03)	9.8 (12/01)	9.1 (12/1)
Chlorides, mg/l	100 (11/12)	100 (11/12)	172 (11/10)	48 (11/12)	100 (12/2)	100 (12/2)	126 (12/1)	120 (12/1)
Specific								
conductance,	350 (11/12)	410 (11/12)	650 (11/10)	200 (11/10)	340 (12/2)	400 (12/2)	500 (12/1)	400 (12/1)
umhos/cm								

Water Quality Analysis, 2005

Andover Water Plant
Andover, Mass.

Sodium, Standard Methods 18th Ed., 3111B
Calcium, Standard Methods 18th Ed., 3111B
Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0
Specific Conductance, Standard Methods 18th Ed., 2510B

	January, 2005				**February, 2005**			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	45.4 (1/10)	48.2 (1/10)			48.9 (2/9)	50.1 (2/9)		
Calcium, mg/l	11.9 (1/25)	11.3 (1/25)	**OFF**		12.7 (2/18)	12.2 (2/18)	**OFF**	
Chlorides, mg/l	98 (1/25)	100 (1/25)			100 (2/18)	102 (2/18)		
Specific								
conductance,	380 (1/25)	440 (1/25)			400 (2/18)	450 (2/18)		
umhos/cm								

	March, 2005				**April, 2005**			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	50.4 (3/3)	52.2 (3/3)	203 (3/16)	211 (3/16)	60.9 (4/26)	61.4 (4/26)		
Calcium, mg/l	12.4 (3/18)	11.6 (3/18)	24.2 (3/16)	24.5 (3/16)	14.3 (4/26)	12.6 (4/26)		
							on 8 days	
Chlorides, mg/l	140 (3/18)	140 (3/18)	430 (3/16)	432 (3/16)	132 (4/22)	126 (4/22)		
Specific								
conductance,	375 (3/3)	420 (3/3)	1400 (3/16)	1450 (3/16)	425 (4/22)	470 (4/25)		
umhos/cm								

	May, 2005				June, 2005			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	62.7 (5/6)	63.7 (5/6)			64.5 (6/21)	67.1 (6/21)	77.2 (6/8)	23 (6/8)
Calcium, mg/l	15.7 (5/31)	15 (5/31)			14 (6/21)	12.5 (6/21)	18.4 (6/8)	7.8 (6/8)
			OFF					
Chlorides, mg/l	126 (5/16)	128 (5/16)			124 (6/1)	130 (6/1)	316 (6/8)	124 (6/8)
Specific								
conductance,	440 (5/6)	480 (5/6)			480 (6/21)	530 (6/21)	550 (6/8)	220 (6/8)
umhos/cm								

	July, 2005				August, 2005			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	66 (7/27)	68.8 (7/27)	79 (2/27)	31 (7/27)	51 (8/15)	53.5 (8/15)	41 (8/10)	23.6 (8/10)
Calcium, mg/l	18.3 (7/27)	17.2 (7/27)	18 (7/27)	9 (7/27)	13.4 (8/15)	13.5 (8/15)	14.5 (8/10)	8.7 (8/10)
Chlorides, mg/l	130 (7/26)	136 (7/26)	120 (7/27)	60 (7/27)	120 (8/2)	126 (8/2)	120 (8/10)	128 (8/10)
Specific								
conductance,	450 (7/26)	550 (7/26)	500 (7/27)	250 (7/27)	440 (8/10)	500 (8/10)	400 (8/10)	250 (8/10)
umhos/cm								

	September, 2005				October, 2005			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	44 (9/14)	46 (9/14)	17.5 (9/7)	12.9 (9/14)	38 (10/12)	39.5 (10/12)	23 (10/05)	20 (10/05)
Calcium, mg/l	13.2 (9/8)	12.3 (9/8)	6.3 (9/7)	4 (9/7)	11.8 (10/12)	11.3 (10/12)	9.2 (10/5)	6.9 (10/12)
Chlorides, mg/l	92 (9/14)	90 (9/14)	40 (9/7)	32 (9/7)	80 (10/7)	86 (10/7)	46 (10/5)	46 (10/5)
Specific								
conductance,	350 (9/8)	425 (9/8)	150 (9/7)	175 (9/7)	325 (10/6)	360 (10/6)	225 (10/5)	200 (10/5)
umhos/cm								

	November, 2005				December, 2005			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	40 (11/17)	41.8 (11/17)			30.6 (12/15)	31.1 (12/15)		
Calcium, mg/l	10 (11/16)	9.2 (11/16)			11.2 (12/15)	10.6 (12/15)		
			OFF				**OFF**	
Chlorides, mg/l	72 (11/17)	82 (11/17)			80 (12/06)	84 (12/06)		
Specific								
conductance,	325 (11/16)	375 (11/16)			300 (12/06)	350 (12/05)		
umhos/cm								

Sodium, Standard Methods 18th Ed., 3111B

Water Quality Analysis, 2006

Calcium, Standard Methods 18th Ed., 3111B

Andover Water Plant
Andover, Mass.

Chlorides, Methods for Det. Inorg. Sub. In Env. Samples, 300.0
Specific Conductance, Standard Methods 18th Ed., 2510B

	January, 2006				February, 2006			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	43.4 (1/4)	43 (1/4)	85 (1/3)	21 (1/3)	47.2 (2/3)	47.4 (2/3)		
Calcium, mg/l	13.3 (1/31/)	12.6 (1/31)			10.8 (2/17)	10.5 (2/17)		
			off	**off**			**off**	**off**
Chlorides, mg/l	90 (1/03)	100 (1/03)			94 (2/3)	96 (2/3)		
Specific								
conductance,	360 (1/31)	425 (1/31)			360 (2/3)	425 (2/3)		
umhos/cm								

	March, 2006				April, 2006			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	44.8 (3/14)	44.6 (3/14)	87.2 (3/15)	23.6 (3/15)	46.9 (4/5)	47.8 (4/5)	99.8 (4/3)	29.6 (4/3)
Calcium, mg/l	11 (3/13)	10.5 (3/13)	18.7 (3/15)	6.1 (3/15)	12.8 (4/11)	12.3 (4/11)	28 (4/3)	9 (4/3)
Chlorides, mg/l	94 (3/20)	94 (3/20)	176 (3/15)	50 (3/15)	106 (4/11)	100 (4/11)	194 (4/3)	60 (4/11)
Specific								
conductance,	350 (3/2)	425 (3/2)	650 (3/15)	225 (3/15)	350 (4/3)	430 (4/3)	700 (4/3)	275 (4/3)
umhos/cm								

	November, 2004				December, 2004			
	Raw	Finish	Fishbrook	Merrimack	Raw	Finish	Fishbrook	Merrimack
Sodium, mg/l	47.6 (11/15)	49.1 (11/15)	98.4 (11/10)	18.9 (11/10)	47.8 (12/2)	48.4 (12/2)	59.3 (12/1)	56.3 (12/1)
Calcium, mg/l	12.3 (11/15)	11.1 (11/15)	17.0 (11/10)	5.5 (11/10)	12.3 (12/03)	10 (12/03)	9.8 (12/01)	9.1 (12/1)
Chlorides, mg/l	100 (11/12)	100 (11/12)	172 (11/10)	48 (11/12)	100 (12/2)	100 (12/2)	126 (12/1)	120 (12/1)
Specific								
conductance,	350 (11/12)	410 (11/12)	650 (11/10)	200 (11/10)	340 (12/2)	400 (12/2)	500 (12/1)	400 (12/1)
umhos/cm								

APPENDIX D
TOWN LANDFILL
Ledge Road

Background

The Andover Town Landfill is a former stone quarry that began use as a municipal waste dump accepting both residential and industrial wastes following World War II. Open dumps and the burning of trash were acceptable methods of dealing with solid waste in that time. Residents reportedly socialized at the dump, politicians stumped at the dump, and children played in the environs around the dump. It is reported that prior to the dump being opened, residents swam in swimming holes fed by streams flowing out of the quarry, and climbed in the trees at the base of the quarry, whose tops were level with the edge of aptly named Ledge Road.

Various types of wastes are reportedly dumped at the Town Landfill. For example, quoted in the initial site assessment performed by the Town's consultant Camp, Dresser, and McKee in 1995: In 1969 the technical director of Reichold Chemical wrote to the Andover Town Manager describing what his company dumped at Ledge Rd.: "In answer to your request for contents of drums sent to the town dump by Reichold Chemicals, we dispose of non-flammable plastic resin and resin solutions only. In the case of liquid resins and solutions, our men drain the contents, leaving no drum filled or partially filled, with the bung caps off. In addition to drums we also dispose of fibre kegs with general refuse and salt residues from our manufacturing operations." Other regular industrial users of the landfill recalled by long-time residents include Gillette, Raytheon, Converse, and Tyer Rubber. There are also unconfirmed reports of attendants of the dump being paid to accept undesirable chemical wastes.

There is a long historical record of the detection of many environmental insults linked to the landfill. A United States Environmental Protection Agency report available on the web (http://yosemite.epa.gov/r1/npl_pad.nsf/0/637c892d92b7ed0e85256b4200604956?OpenDocument) details some of the history:

- A 1961 site examination report indicated that the property was being operated as an open face dump with insufficient, if any, clean cover material being applied to the waste. Numerous fires along the perimeter of the dump face were also reported. In 1972, the Massachusetts Department of Public Health (MA DPH) determined that leachate from the landfill was polluting a brook that was upstream of a surface water drinking water intake operated by the Town of Andover. Analytical results of leachate samples collected by MA DPH indicated the presence of zinc, chromium, and other metals. Later in 1972, MA DPH ordered the Town of Andover to close the landfill and to construct piping and works to divert and control groundwater entering the landfill and to substantially eliminate the flow of leachate to the brook. A drain was subsequently installed in 1972 to intercept groundwater flowing into the landfill. In 1973, the landfill stopped accepting waste, with the exception of brush from Andover residents, which was accepted until 1992. Since 1992, only the Town of Andover disposes of brush on the property. The Town of Andover capped the landfill with one foot of clay and five feet of loam fill in 1988 and subsequently developed a portion of the property as an outdoor athletic facility. Previous U.S. Environmental Protection Agency investigations at the property have included: a 1980 Preliminary Assessment, a 1987 Site Inspection, and a 1996 Site Inspection Prioritization.

- An estimated 1,339 people are served by private drinking water supply wells located within 4-radial miles of the property. The nearest private drinking water supply well is located approximately 0.25 miles southwest of the property. No known public drinking water supply wells are located within 4-radial miles of the property. Groundwater occurs in overburden at a depth of 18 to 28 feet (ft) below ground surface (bgs), and groundwater flow is to the southwest. Analytical results of groundwater samples collected from on-site monitoring wells in 1982, 1984, 1986, and 1995 indicated the presence of inorganic elements and volatile organic compounds (VOCs) including benzene, toluene, xylenes, trichloroethylene (TCE), and tetrachloroethylene (PCE). Potential impacts to nearby groundwater drinking water supply sources are unknown.

  Stormwater runoff from the property flows southwest to two unnamed streams located along the western boundary of the property. Additional surface water bodies located along the 15-mile surface water pathway include Fish Brook and Merrimack River. Four drinking water intakes, serving a total of 140,900 people, are located along the 15-mile downstream surface water pathway: one on Fish Brook and three along Merrimack River in Andover, Methuen, and Lawrence. Approximately 5 miles of wetlands frontage, a Clean Water Act (CWA)-protected water body, fisheries, and one State-listed threatened species habitat are located along the 15-mile downstream surface water pathway. Analytical results of surface water pathway samples collected in 1972, 1982, 1984, 1986, and 1995 from the unnamed streams indicated the presence of three VOCs, six semivolatile organic compounds (SVOCs), four pesticides, and nine metals. Based on the analytical results, a CWA-protected water body and wetlands have been impacted.

  There are no residents, workers, or terrestrial sensitive environments on the property. Approximately 2,970 people reside within 1-radial mile of the property. No residences, schools, or day-care centers are located within 200 feet of the property. Property access is unrestricted. Analytical results of surface soil samples collected in 1989 from the property indicated the presence of three VOCs, seven SVOCs, and 15 metals, including lead. Based on site observations and conditions and lack of property access restrictions, potential impacts to nearby residential populations are unknown.

The private well mentioned in the above report was on the McGrath property just down gradient from the landfill. Soon after this report was filed the Town closed the private well on the McGrath property and provided Town water. Harold McGrath died of leukemia in the mid 1980's. Ruth McGrath lives with her daughter in Maine. The Town bought the McGrath property in 2003. The home was razed.

Groundwater at the Town landfill occurs in overburden at a depth of 18 to 28 feet (ft) below ground surface (bgs), and groundwater flow is to the southwest. Stormwater runoff from the property also flows southwest to two unnamed surface water streams located along the western boundary of the property. Additional surface water bodies located along the water pathway include Fish Brook and Merrimack River.

Site Assessment

There is an extensive record of environmental contaminants linked to the Town landfill detected in the surrounding surface waters, groundwater, and soils.

Surface Water Analyses

In 1972, the Massachusetts Department of Public Health (MA DPH) determined that leachate from the landfill was polluting a brook that was upstream of Fish Brook. Analytical results of leachate samples collected by MA DPH indicated the presence of zinc, chromium, and other metals.

Analytical results of surface water pathway samples collected in 1972, 1982, 1984, 1986, and 1995 from the unnamed streams determined the presence of three(3) VOCs, six(6) semivolatile organic compounds (SVOCs), four(4) pesticides, and nine(9) metals.

Surface water sampling conducted in 2005 by the Fish Brook Initiative determined the presence of arsenic at levels as high as ten(10) times the federal drinking water standard. Eight(8) VOCs listed in the Massachusetts Surface Water Quality Standards as toxic pollutants were also detected in the same streams.

Groundwater Analyses

Analytical results of groundwater samples collected from on-site monitoring wells in 1982, 1984, 1986, and 1995 indicated the presence of inorganic elements and volatile organic compounds (VOCs) including benzene, toluene, xylenes, trichloroethylene (TCE), and tetrachloroethylene (PCE).

Soil Analyses

Analytical results of surface soil samples collected in 1989 from the property indicated the presence of three(3) VOCs, seven(7) SVOCs, and fifteen(15) metals, including lead.

Conclusions

Based upon analytical results, site observations and present conditions, the Fish Brook Initiative Task Force considers the Ledge Road landfill to pose a current environmental threat. The landfill is clearly situated to adversely impact Fish Brook and the Andover public drinking water supply if significant quantities of pollutants are released from the site. The Task Force believes the following issues should be addressed in the immediate future to help mitigate further threat.

- The design, intention and future impact of a poorly maintained piping system often referred to as “under drains” installed around the landfill needs to be examined.
- The scope of the area considered part of the Andover Town Landfill requires evaluation. Information gathered from long-time residents indicates residential and industrial wastes

were dumped in an area adjacent to the landfill bordered by Chandler Road, Greenwood Road, and Ledge Road, which is upgradient from the area now being considered by the Town for capping. This uncapped area of the landfill may compromise the effectiveness of the impending landfill recap.

- The last Comprehensive Site Assessment asserted that there were no sensitive receptors affected by the contaminated leachate flowing out of the landfill as it falsely identified the relative location of the public water supply. A thorough evaluation by the Fish Brook Initiative indicates that three (3) Class A protected water bodies and wetlands have been adversely impacted, as well as potential impacts to nearby residents and farm animals. Any portion of Fish Brook, including its tributaries, should be considered sensitive receptors as they contribute to the public water supply. Higher than normal arsenic levels and VOCs in the leachate stream flowing off the landfill, and a comprehensive study of the impact of these contaminants on any section of Fish Brook needs to be undertaken and presented to the citizens of Andover.

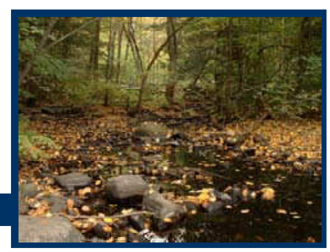
APPENDIX E
FISH BROOK INITIATIVE PRESENTATION
By Cyndi Vaughn

FISH BROOK INITIATIVE

Task Force

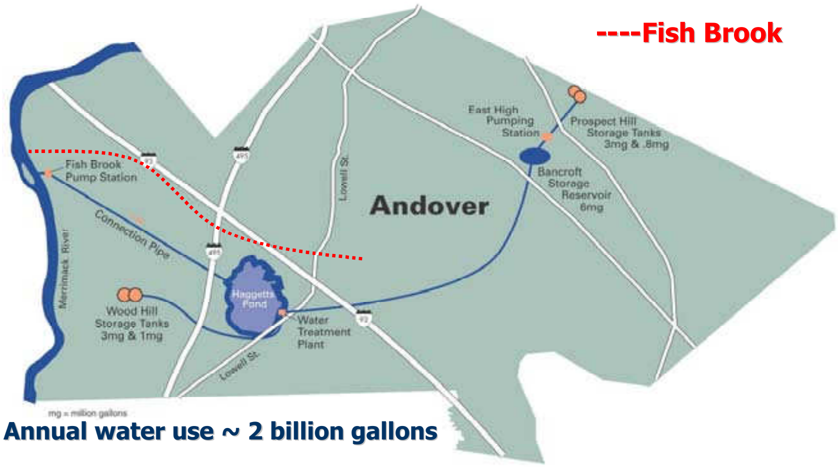
December 2003

FISH BROOK



- **5.25 mile long stream**
- **Arises in wetlands near Haggetts Pond and from the ponds in Indian Ridge Country Club**
- **Travels through a heavily developed residential area, passes under I-93 and I-495**
- **Shortly thereafter empties into a lagoon built over at the Fish Brook Pumping Station**
- **Becomes part of the public drinking water supply**

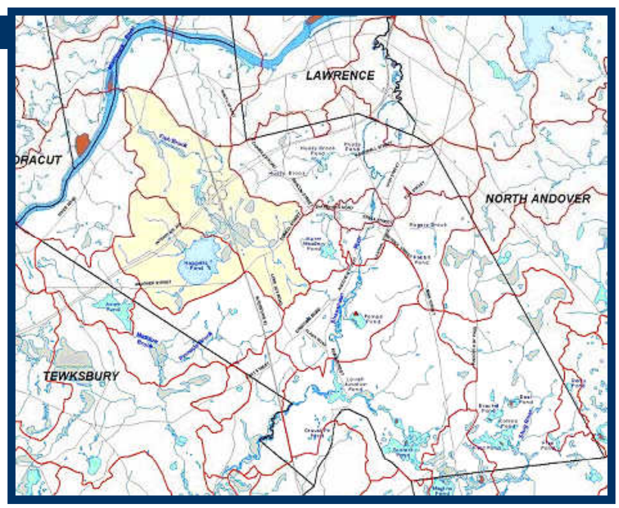
WATER SUPPLY MECHANICS



Annual water use ~ 2 billion gallons

WATERSHED BOUNDARY

Fish Brook watershed area: 2450 acres



CLASS "A" STREAM
Outstanding Resource Waters

Massachusetts Surface Water Quality Standards 314 CMR

- Designated for protection as Outstanding Resource Waters under MA regulations
- Designated as a source of public water supply
- Shall be an excellent habitat for fish, other aquatic life and wildlife
- Shall be suitable for primary and secondary contact recreation
- Shall have excellent aesthetic value

MINIMUM CRITERIA CLASS A

- **Dissolved oxygen** (>6 ppm, daily/seasonal variations)
- **Temperature** (Rise in T due to discharge <1.5 °F)
- **pH** (6.5-8.3)
- **Fecal coliform bacteria** (<20/100 ml ave.)
- **Solids** (Free from floating, suspended & settleable solids)
- **Color & Turbidity** (levels < would impair use)
- **Synthetic pollutants** (Free from oil & grease, petrochemicals, VOCs)

Protect species diversity, growth of aquatic life, & PWS

SURFACE WATER PROTECTION ZONES

DEP delineates precautionary areas or zones within a watershed that place restrictions on land use activity within the zones.

Zone A: is the area 400 feet from the edge of the reservoir and 200 feet from the edge of the tributaries draining into it. It is the most critical for protection efforts.

Zone B: is the area one-half mile from the edge of the reservoir, but does not go beyond the outer edge of the watershed.

Zone C: is the remaining area in the watershed not designated as Zone A or B.

DPW PROTECTION

Both new to Andover for 2003

Multi-barrier protection of the drinking water system:

SOURCE

TREATMENT

DISTRIBUTION

#1

SWSPP

Surface Water Supply Protection Plan

#2

SMP

Stormwater Management Plan

SWSPP

Surface Water Supply Protection Plan

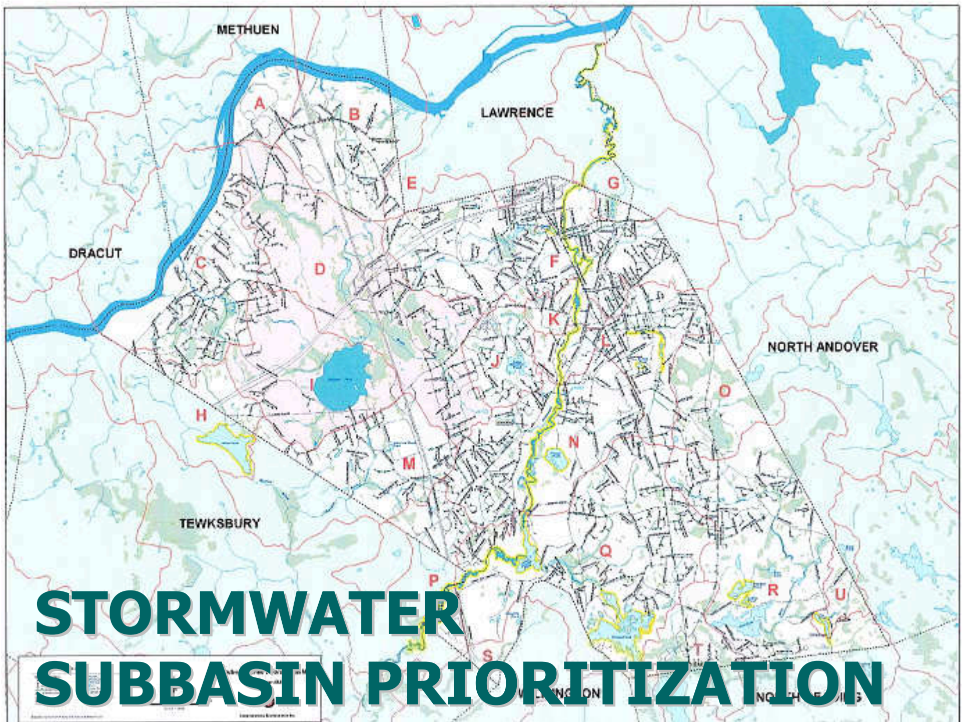
- Potential sources of contamination in the watershed
- Careful look at existing land uses
- Inventory of facilities and activities
- Assessment of potential threats to water quality

EPA NPDES
PHASE II RULE

STORMWATER MANAGEMENT PLAN (SMP)

Stormwater is not a contamination source, but is a conduit for pollutant transport to surface waters.

- Requires the town to develop, implement, and enforce a program to reduce pollutants in stormwater runoff entering the municipal storm drain.
- SMP delineated the town into subwatersheds to help prioritize implementation of Phase II activities
- Fish Brook (area D) ranked high priority



STORMWATER SUBBASIN PRIORITIZATION

WAS FISH BROOK ASSESSED?

303d LIST

DEP was responsible for:

- **Monitoring all MA surface waters**
- **Identifying those waters that are impaired**
- **Developing a plan to bring them back into compliance with the Massachusetts Surface Water Quality Standards**
- **Hence the 303d list**

303d LIST
Impaired Waters in Andover

Name	Description	Size	Assessment Date	Pollutant Needing TMDL
Brackett Pond	Andover	17 acres	Apr-97	Turbidity
Collins Pond	Andover	7 acres	Apr-97	Noxious aquatic plants, Turbidity
Frye Pond	Andover	6 acres	Apr-97	Noxious aquatic plants
Fosters Pond	Andover/Wilmington	135 acres	Sep-02	Metals, Exotic species
Hussey Pond	Andover	2 acres	Apr-97	Noxious aquatic plants
Lowell Junction Pond	Ballardvale Pond, Andover	40 acres	Apr-97	Metals, Noxious aquatic plants, Exotic species
Pomps Pond	Andover	14 acres	Sep-02	Metals, Exotic species
Rabbit Pond	Andover	5 acres	Apr-97	Turbidity
Rogers Brook	Andover	1.3 acres	Apr-97	Pathogens, Turbidity
Shawsheen River	Andover	17.4 miles	Apr-97	Unknown toxicity, Metals, Low Dissolved Oxygen, Pathogens

POTENTIAL INSULTS

Golf courses

Residential lawns/ponds

UST leaks

Roadways

Gas stations

Salt storage

Agricultural runoff

Development

APPENDIX F

GROUNDWATER IRON AND ARSENIC ISSUES
Presented By David Adilman

Groundwater Iron and Arsenic Issues Related to Landfills

Warren Brady (Baton Rouge)
Don Strickland (Tampa)
Herwig Goldemund (Atlanta)

GeoSyntec Consultants

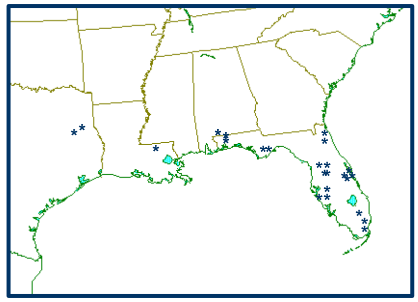
OUTLINE

- Overview
- Geochemical Models
- Groundwater Reduction Sources
- Completing the Site Conceptual Model
- Developing Strategies for Management
- Conclusions

GeoSyntec Consultants

OVERVIEW

- **Regulatory Drivers**
  - **Arsenic – lowering of groundwater MCL from 50 μg/L to 10 μg/L**
  - **Iron – enforcement of secondary water standard (300 μg/L)**
  - **Surface water quality standards for both constituents**
  - **Potential revision of C&D landfill construction requirements (CCA Task Force)**
- **Groundwater exceedance may be directly and/or indirectly associated with landfill development**

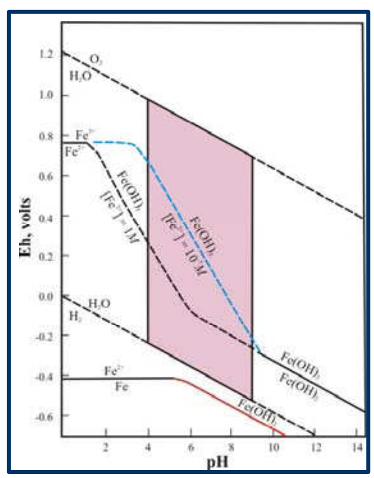


* Landfill sites where GeoSyntec has provided iron and/or arsenic groundwater management services

GeoSyntec Consultants

GEOCHEMICAL MODELS - IRON

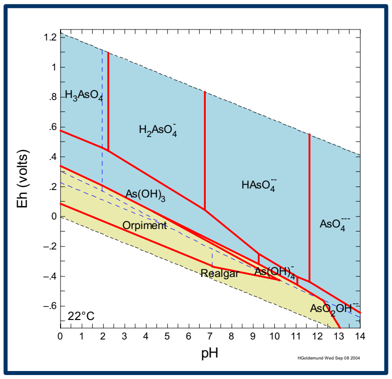
- Nature and Abundance
  - Typical iron range in soils is 0.5% to 5%
  - Average crustal abundance of iron is 5% by weight
- Geochemistry
  - Generally more soluble under reducing conditions
    - (Ferrous Iron – Fe^{2+})
  - Generally forms insoluble ferri-hydroxide minerals under more oxidizing conditions
    - (Ferric iron – Fe^{3+})



GeoSyntec Consultants

GEOCHEMICAL MODELS - ARSENIC

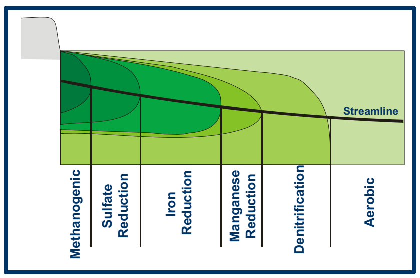
- Arsenic is generally present in two forms: arsenate (5+) and arsenite (3+)
  - As(5+) generally carries a negative charge
  - As(3+) is generally uncharged
- Sorption is greatest for As(5+) and minimal for As(3+)
- Under reducing conditions (low redox potential), As(3+) is the dominant form
  - Higher solubility (mobility) and toxicity, no charge
  - Potential precipitation as sulfides (e.g., orpiment, realgar)



GeoSyntec Consultants

GEOCHEMICAL MODELS - LANDFILLS

- **Landfill leachate**
  - **Generally reducing with high levels of organic material and various ions**
  - **Influx of nutrients and carbon enhances biological metabolic processes**
  - **Many of the metabolic pathways utilize redox couples between ferrous iron and ferric iron**
  - **Organic material degradation may take place when ferric iron is used as the terminal electron acceptor**
  - **The product of this reduction will be ferrous iron**
- **Landfill gas has also been shown to induce reducing conditions in groundwater (Henry Kerfoot)**

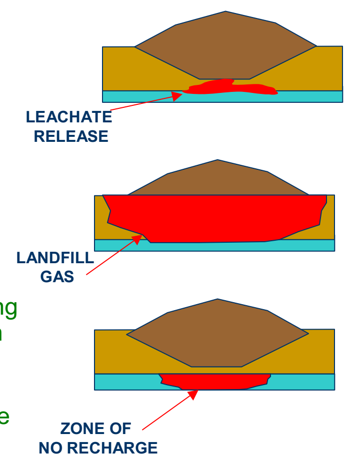


From Christensen *et al.*, *Applied Geochemistry* 16 (2001):659-718

GeoSyntec Consultants

GROUNDWATER REDUCTION SOURCES

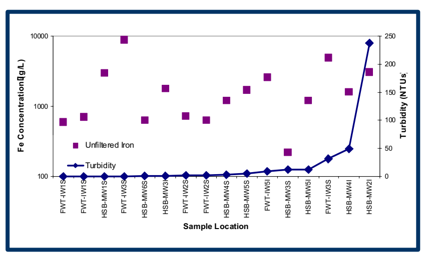
- Groundwater may become reduced through direct leachate release into groundwater
- Landfill gas may also result in groundwater reduction
- Landfill construction may also result in groundwater reduction
  - Liners, capping, daily covers, and routing of water may all prevent water with high DO (i.e., rainwater) from recharging groundwater beneath a landfill
  - As a result, groundwater underneath the landfill has a limited supply of oxygen
- Others



GeoSyntec Consultants

COMPLETING THE SITE CONCEPTUAL MODEL

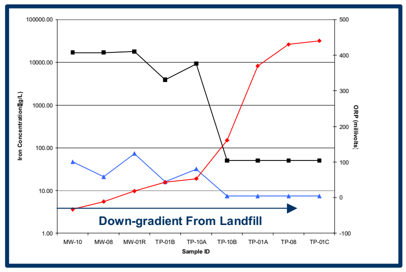
- The right questions!!
  - **Could exceedances be the result of poor sampling?**
  - **What is the source of groundwater reduction?**
  - **How far down-gradient does the reducing zone extend?**
  - **What is the attenuation capacity of the aquifer?**
  - **Will receptors be impacted, at what concentration, and when?**



GeoSyntec Consultants

COMPLETING THE SITE CONCEPTUAL MODEL

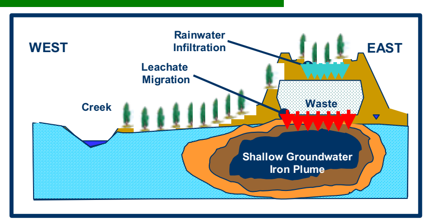
- The tools!!
  - Detailed analysis of landfill construction
  - Down-gradient delineation of COCs and reducing plume
  - Geochemical testing of leachate, groundwater, and surface water
  - Fate and transport modeling
  - Geochemical modeling

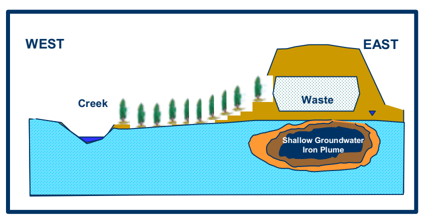


GeoSyntec Consultants

DEVELOPING STRATEGIES FOR MANAGEMENT

- Source Control
  - Infiltration reduction
  - Landfill gas capture
  - Surface water treatment?
- Groundwater Management
  - Zone of Discharge (ZOD) Management
  - Natural Attenuation
  - Passive Remedies
  - Aggressive Remedies





GeoSyntec Consultants

CONCLUSIONS

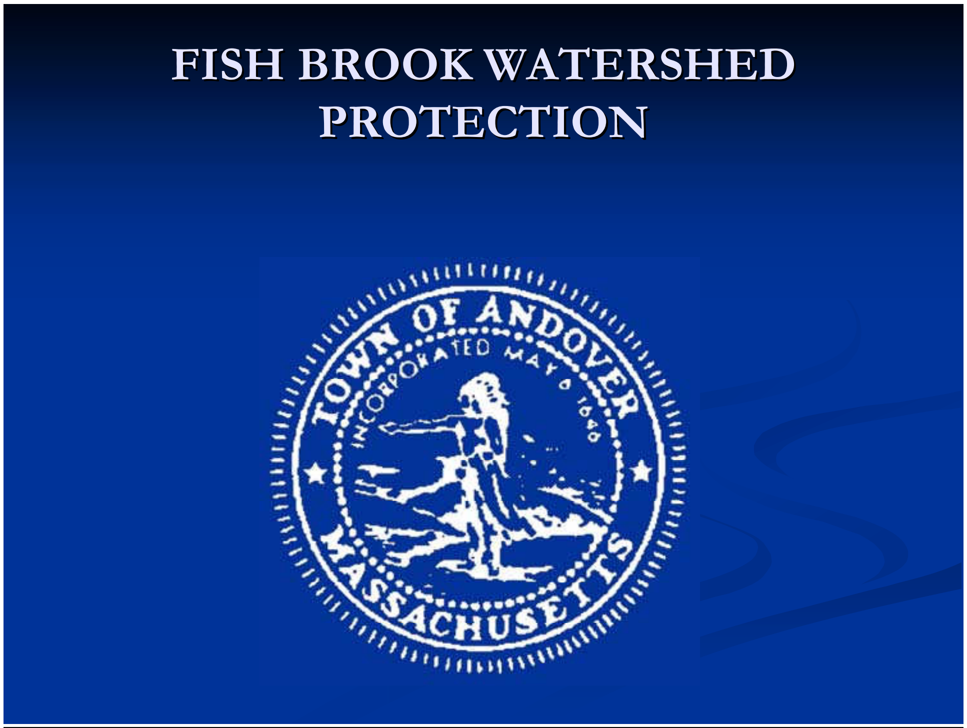
- Impending lowering of the arsenic MCL and strict enforcement of the secondary MCL for iron present challenges for site managers
- Unintended consequences - Iron- and arsenic-related detection may be directly and/or indirectly effected by landfill construction and operation practices
- Development of a site geochemical model is critical to developing management strategies
- Management strategies generally focus on:
  - Source control – specifically if leachate is known to be the source of reduction
  - Down-gradient groundwater migration
- What’s Missing? Assimilative capacity of aquifer !!

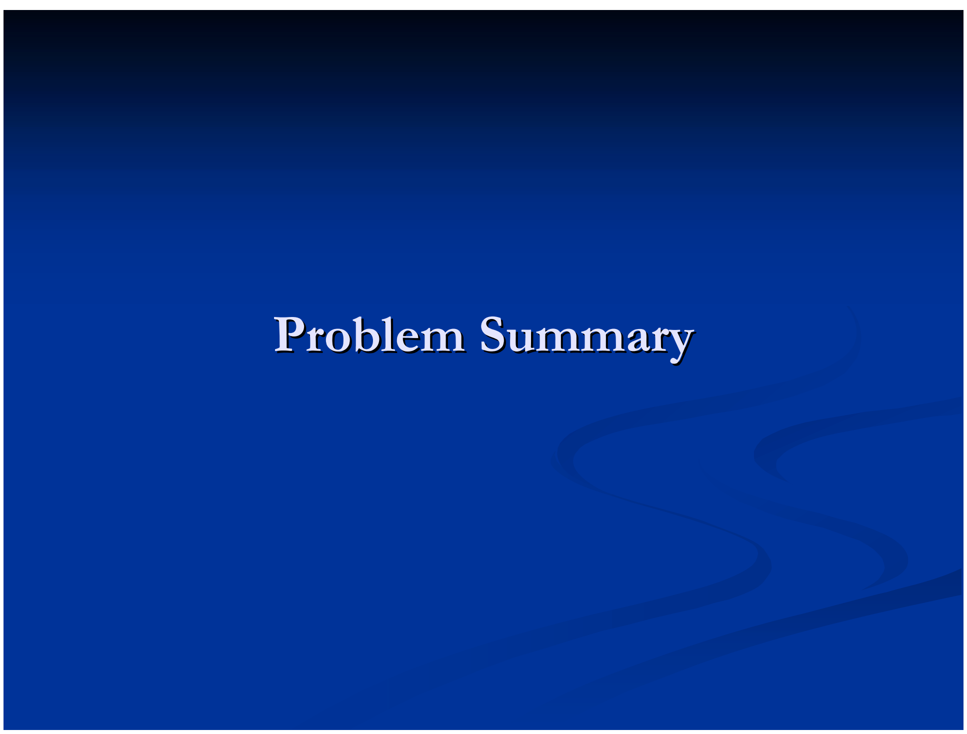
GeoSyntec Consultants

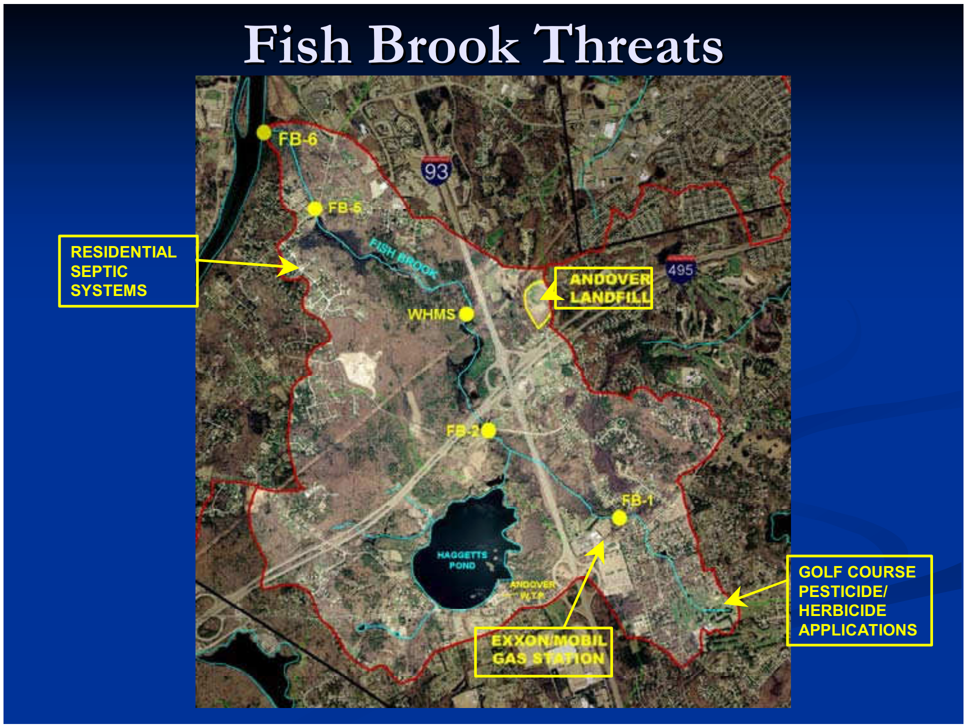
APPENDIX G

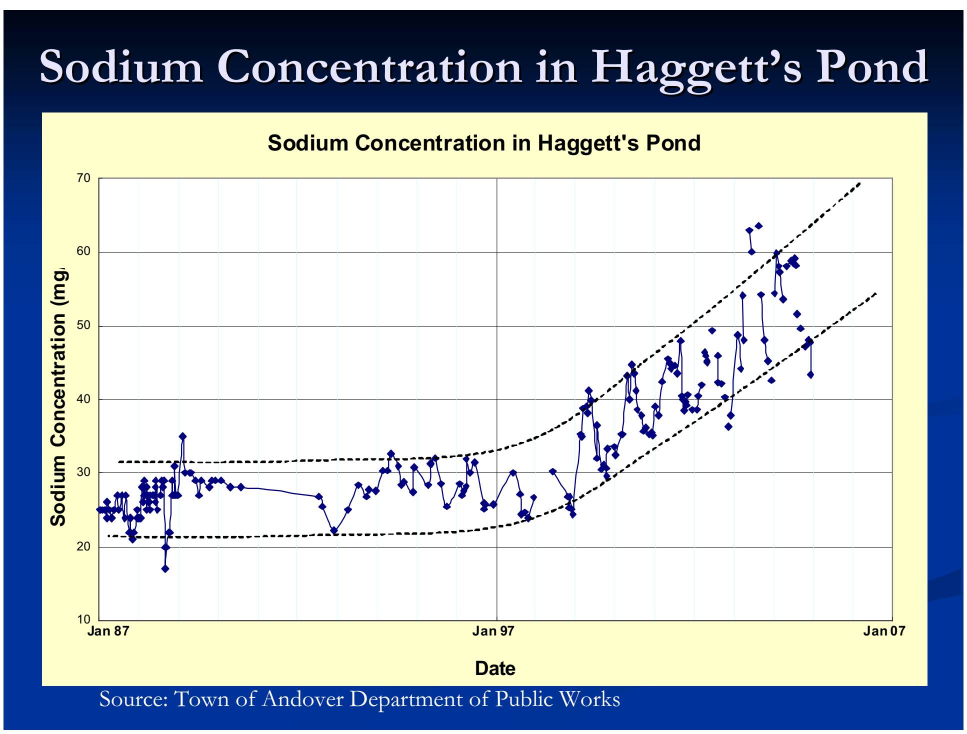
PRESENTATION TO MASS HIGHWAY

By Steve Boynton






Fish Brook Threats
FB-6
FB-5
FISH BROOK
93
495
RESIDENTIAL SEPTIC SYSTEMS
ANDOVER LANDFILL
WHMS
FB-2
FB-1
HAGGETTS POND
ANDOVER W.T.P.
GOLF COURSE PESTICIDE/ HERBICIDE APPLICATIONS
EXXON/MOBIL GAS STATION


Sodium Concentration in Haggett's Pond
Sodium Concentration in Haggett's Pond
Sodium Concentration (mg
70
60
50
40
30
20
10
Jan 87
Jan 97
Jan 07
Date
Source: Town of Andover Department of Public Works

Causes

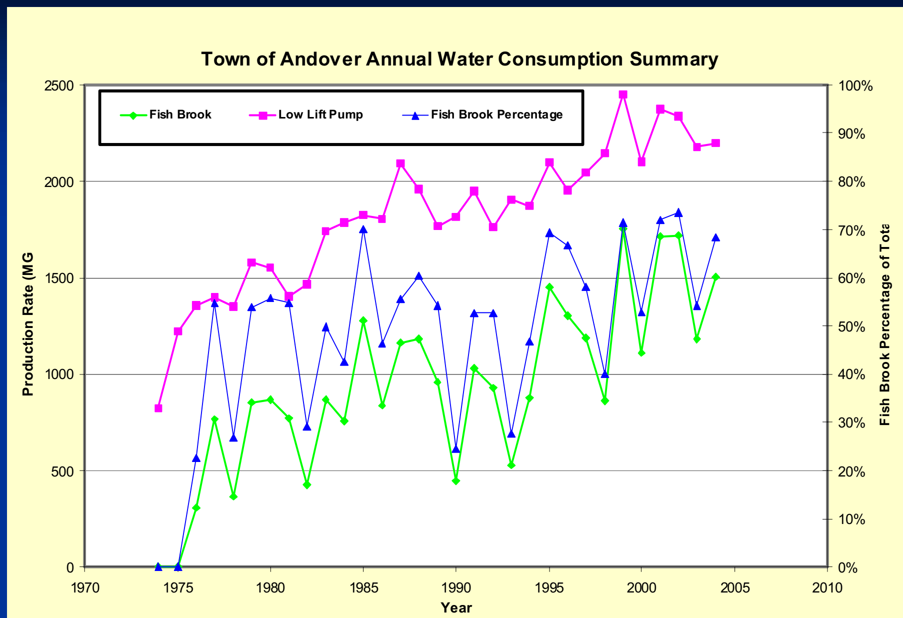
Three Possible Causes

- Salt Storage at the I93/I495 Interchange
- Oversalting of the Interchange
- Change in Statewide Road Salting Policy and Procedures

Haggett's Pond and I93/I495 Interchange

Proximity of I93/I495 Interchange to Fish Brook

Annual Water Use



Impacts

Impact to Residents

- Health Concerns (notification at 20 mg/l)
- Corrosion
- Taste/Aesthetics (taste threshold at 150 mg/l)
- Loss of Water Supply

The Fish Brook Initiative

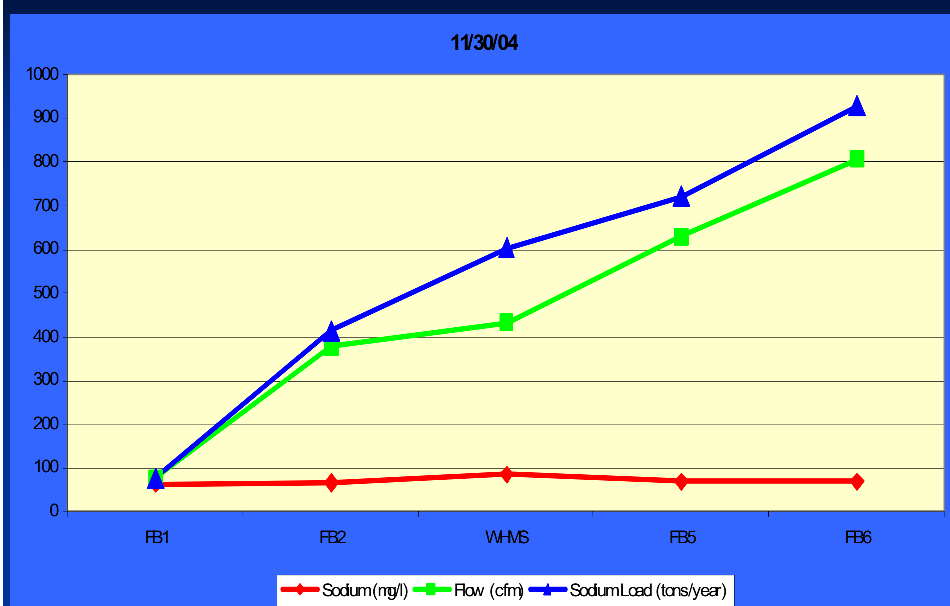
Fish Brook Initiative

- A "Source Water" Protection Committee
- Volunteer Effort (includes Wood Hill Middle School Students)
- Evaluate Potential Sources of Contamination to the Andover Water Supply Source Waters
- Started in 2004
- Fish Brook Flow Measurement and Sampling and Sodium Load Calculations
- Meetings with Exxon/Mobil Consultants
- Meetings with Town Landfill Consultants

Staff Gauges

Wood Hill Middle School Students Participation

Sodium Chloride Data




Fish Brook Salt Loads – 11/30/04
Data Shown is Salt Load in Fish Brook (tons/year)
2360
FB-6
FB-5
1832
FISH BROOK
93
495
WHMS
1537
1050
FB-2
FB-1
202
HAGGETTS POND
ANDOVER WTP

.

APPENDIX I
FLOW DATA

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-1 (Fish Brook at Greenwood Road)
Date: 11/5/2004 Time: 07:00
Samplers: T. Brady, S. Boynton
Staff Gauge Re 1.95 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0	0	0.0		
1	0.5	0	0.0		
2	0.84	0	0.0		
3	0.66	0	0.0		
4	0.64	0.44	16.9		
5	0.6	0.45	16.2		
6	0.54	0.91	29.5		
7	0.52	0.9	28.1	175	cu ft/min
8	0.48	0.57	16.4	2.9	cu ft/sec
9	0.7	0.69	29.0	1307	gpm
10	0.62	0.63	23.4	1.88	mgd
11	0.62	0.41	15.3		
12	0.7	0	0.0		
13	0	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-1 (Fish Brook at Greenwood Road)
Date: 11/5/2004 Time: 07:00
Samplers: T. Brady, S. Boynton
Staff Gauge Re 1.95 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0	0	0.0		
1	1.04	0	0.0		
2	1.12	0.19	12.8		
3	1.06	0.31	19.7		
4	1	0.26	15.6		
5	1	0.38	22.8		
6	1.06	0.24	15.3		
7	0.8	0.15	7.2	151	cu ft/min
8	0.84	0.24	12.1	2.5	cu ft/sec
9	0.8	0.35	16.8	1129	gpm
10	0.88	0.28	14.8	1.63	mgd
11	0.7	0.33	13.9		
12	0.84	0	0.0		
13	0	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-1 (Fish Brook at Greenwood Road)
Date: 11/9/2004 Time: 02:00
Samplers: T. Brady
Staff Gauge Re 1.66 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0	0	0.0		
1	0.5	0	0.0		
2	0.45	0	0.0		
3	0.45	0	0.0		
4	0.35	0	0.0		
5	0.35	0.12	2.5		
6	0.35	0.36	7.6	14	cu ft/min
7	0.35	0.21	4.4	0.2	cu ft/sec
8	0.25	0	0.0	108	gpm
9	0.25	0	0.0	0.16	mgd
10	0.5	0	0.0		
11	0.4	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-1
Date: 11/29/2004 Time: 12:00 PM
Samplers: T. Brady
Staff Gauge Re 1.90 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0	0	0.0		
1	0.75	0	0.0		
2	0.65	0	0.0		
3	0.65	0.47	18.3		
4	0.55	0.31	10.2		
5	0.5	1.34	40.2		
6	0.5	1.31	39.3		
7	0.5	1.13	33.9		
8	0.5	0.42	5.0	221	cu ft/min
9	0.6	0.85	30.6	1655	gpm
10	0.65	0.78	30.4	2.38	mgd
11	0.6	0.37	13.3		
12	0.4	0	0.0		
13	0.4	0	0.0		
14	0	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-1

Date: 1/14/2005 Time: 11:30 AM

Samplers: T. Brady

Staff Gauge Re 2.54 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min
0	0	0	0.0
1	0.4	0	0.0
2	0.85	0	0.0
3	1.3	0.24	18.7
4	1.2	1.07	77.0
5	1.1	2.06	136.0
6	1.1	3.06	202.0
7	1.1	4.02	265.32
8	1.1	4.23	279.2
9	0.9	4.21	227.3
10	1	3.13	187.8
11	1.1	3.62	238.9
12	1.2	3.42	246.2
13	1	2.64	158.4
14	1	1.28	76.8
15	0.9	0.57	30.78
16	0.8	0	43.2
17	0.6	0	0
18	0.4	0	0

2188 cu ft/min
16365 gpm
23.57 mgd

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-1

Date: 12/11/2004 Time: 3:00 PM

Samplers: T. Brady

Staff Gauge Re 2.10 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min
0	0	0	0.0
1	0.7	0	0.0
2	1	0.17	10.2
3	1	0.62	37.2
4	0.9	1.04	56.2
5	0.8	1.04	49.9
6	0.8	1.2	57.6
7	0.8	1.09	52.32
8	0.7	0.79	33.2
9	0.8	0.94	45.1
10	0.9	1.01	54.5
11	0.7	0.68	28.6
12	0.6	0.68	24.5
13	0.6	0.13	4.7
14	0.6	0	0.0
15	0.4	0	0

454 cu ft/min
3396 gpm
4.89 mgd

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-2 (Fish Brook at High Plain Road)
Date: 11/5/2004 Time: 09:15
Samplers: T. Brady
Staff Gauge Re 1.24 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0.6	0.36	13.0		
1	1.3	0.78	60.8		
2	1.2	0.72	51.8		
3	0.9	0.54	29.2		
4	1.3	0.78	60.8	548	cu ft/min
5	1.3	0.78	60.8	9.1	cu ft/sec
6	1.55	0.93	86.5	4102	gpm
7	1.5	0.9	81.0	5.91	mgd
8	1.3	0.78	60.8		
9	1.1	0.66	43.6		
	1.205	0.723			
		7.840935			

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-2 (Fish Brook at High Plain Road)
Date: 11/9/2004 Time: 09:15
Samplers: T. Brady
Staff Gauge Re 1.18 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0.6	0	0.0		
1	1.2	0.25	18.0		
2	1.1	0.31	20.5		
3	1.2	0.18	13.0		
4	1.4	0.14	11.8		
5	1.5	0.15	13.5		
6	1.4	0.12	10.1	113	cu ft/min
7	1.3	0.21	16.4	1.9	cu ft/sec
8	1.3	0.12	9.4	842	gpm
9	1	0	0.0	1.21	mgd
	1.2				

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-2 Greenwood Road
Date: 11/29/2004 Time: 12:30 PM
Samplers: T. Brady
Staff Gauge Re 1.50 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0.9	0.33	17.82		
1	1.55	0.77	71.61		
2	1.4	1.17	98.28	459	cu ft/min
3	1.3	1.09	85.02	3435	gpm
4	1.6	0.67	64.32	4.95	mgd
5	1.8	0.49	52.92		
6	1.8	0.24	25.92		
7	1.75	0.23	24.15		
8	1.6	0.2	19.2		
9	1.4	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-2 Greenwood Road
Date: 12/11/2004 Time: 3:35 PM
Samplers: T. Brady
Staff Gauge Re 1.76 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.1	0.33	21.78		
1	1.8	1.03	111.24		
2	1.7	0.89	90.78		
3	1.5	0.87	78.3	642	cu ft/min
4	1.7	0.86	87.72	4804	gpm
5	1.9	0.86	98.04	6.92	mgd
6	2.1	0.637	80.262		
7	2	0.38	45.6		
8	1.9	0.25	28.5		
9	1.6	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-2 Greenwood Road
Date: 3/29/2005 Time: 12:00PM
Samplers: T. Brady
Staff Gauge Re 2.40 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	2.4	0	0		
1	2.4	1.5	216		
2	2.4	2.71	390.24		
3	2.4	2.77	398.88	2127	cu ft/min
4	2.4	2.82	406.08	15908	gpm
5	2.5	2.37	355.5	22.91	mgd
6	2.6	0.75	117		
7	2.6	0.68	106.08		
8	2.4	0.65	93.6		
9	2.4	0.3	43.2		

h Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-2 Greenwood Road
Date: 1/14/2005 Time: 12:29 PM
Samplers: T. Brady
Staff Gauge Re 1.60 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0.95	0	0		
1	1.65	0.62	61.38		
2	1.5	0.51	45.9		
3	1.23	0.97	71.586	447	cu ft/min
4	1.7	0.56	57.12	3346	gpm
5	1.6	0.51	48.96	4.82	mgd
6	1.8	0.57	61.56		
7	1.85	0.64	71.04		
8	1.6	0.31	29.8		
9	1.5	0	0.0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 10/30/2004 Time: 08:00
Samplers: T. Brady
Staff Gauge Re 1.36 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.7	0.19	9.7		
1	1.85	0.13	14.4	105	cu ft/min
2	1.91	0.12	13.8	1.8	cu ft/sec
3	1.8	0.19	20.5	788	gpm
4	1.7	0.21	21.4	1.13	mgd
5	1.7	0.2	20.4		
6	1.7	0.1	5.1		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 11/3/2004 Time: 08:00
Samplers: T. Brady
Staff Gauge Re 1.36 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.6	0.2	9.6		
1	1.8	0.15	16.2	96	cu ft/min
2	1.8	0.17	18.4	1.6	cu ft/sec
3	1.7	0.14	14.3	715	gpm
4	1.6	0.17	16.3	1.03	mgd
5	1.6	0.16	15.4		
6	1.4	0.13	5.5		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 11/5/2004 Time: 10:00
Samplers: T. Brady
Staff Gauge Re 1.46 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.6	0.96	46.1		
1	1.95	1.17	136.9	674	cu ft/min
2	2	1.2	144.0	11.2	cu ft/sec
3	1.8	1.08	116.6	5042	gpm
4	1.6	0.96	92.2	7.26	mgd
5	1.6	0.96	92.2		
6	1.6	0.96	46.1		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 11/9/2004 Time: 10:00
Samplers: T. Brady
Staff Gauge Re 1.5 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.5	0.23	10.4		
1	1.9	0.23	26.2		
2	2	0.23	27.6	214	cu ft/min
3	1.8	0.37	40.0	3.6	cu ft/sec
4	1.7	0.42	42.8	1604	gpm
5	1.5	0.54	48.6	2.31	mgd
6	1.5	0.42	18.9		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 11/11/2004 Time: 4:05 PM
Samplers: T. Brady
Staff Gauge Re 1.44 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.8	0.16	8.6		
1	1.8	0.27	29.2	181	cu ft/min
2	2	0.25	30.0	1351	gpm
3	1.7	0.24	24.5	1.95	mgd
4	1.7	0.33	33.7		
5	1.6	0.42	40.3		
6	1.5	0.32	14.4		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 11/26/2004 Time: 2:45 PM
Samplers: T. Brady
Staff Gauge Re 1.5 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	1.6	0.38	18.2		
1	2	0.38	45.6		
2	2	0.28	33.6	306	cu ft/min
3	1.9	0.36	41.0	2288	gpm
4	1.9	0.71	80.9	3.29	mgd
5	1.8	0.52	56.2		
6	1.8	0.56	30.2		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 11/29/2004 Time: 1:00 PM
Samplers: T. Brady
Staff Gauge Re 2.04 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	2.1	0.75	47.3		
1	2.5	0.76	114.0		
2	2.6	1.06	165.4	955	cu ft/min
3	2.4	1.05	151.2	7143	gpm
4	2.3	1.3	179.4	10.29	mgd
5	2.3	1.43	197.3		
6	2.2	1.52	100.3		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 12/11/2004 Time: 4:00 PM
Samplers: T. Brady
Staff Gauge Re 2.3 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	2.1	0.98	61.7		
1	2.7	1.09	176.6		
2	2.8	1.54	258.7		
3	2.8	1.37	230.2	1382	cu ft/min
4	2.4	1.9	273.6	10335	gpm
5	2.5	1.91	286.5	14.88	mgd
6	2.4	1.31	94.3		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-5 (Fish Brook at River Road)
Date: 1/14/2005 Time: 1:00 PM
Samplers: T. Brady
Staff Gauge Re 2.6 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	2.6	1.75	136.5		
1	2.85	1.85	316.4		
2	3.25	2.09	407.6	2247	cu ft/min
3	3	2.24	403.2	16807	gpm
4	2.8	2.56	430.1	24.20	mgd
5	2.3	2.76	380.9		
6	2.2	2.61	172.3		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)
Date: 11/3/2004 Time: 08:00
Samplers: S. Boynton and T. Brady
Staff Gauge Re 4.16 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0	0	0		
1	0.3	0	0		
2	0.93	0	0		
3	0.55	0	0		
4	0.83	0	0		
5	1.1	0	0		
6	1.13	0	0		
7	1.1	0	0		
8	1.05	0.31	19.5		
9	1	0.51	30.6		
10	0.9	0.41	22.1		
11	0.9	0.57	30.8		
12	0.8	0.64	30.7		
13	0.73	0.41	18.0	160	cu ft/min
14	0.65	0.21	8.2	1196	gpm
15	0.5	0	0	1.72	mgd
16	0.35	0	0		
17	0	0	0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)

Date: 11/9/2004 Time: 08:00

Samplers: T. Brady

Staff Gauge Re 4.3 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0	0	0		
1	0.4	0	0		
2	0.6	0	0		
3	0.9	0	0		
4	1.1	0	0		
5	1.1	0	0		
6	1.1	0	0		
7	1.25	0	0		
8	1.3	0.48	37.4		
9	1.15	0.7	48.3		
10	1	0.35	21.0	267	cu ft/min
11	1	0.85	51.0	1998	gpm
12	1	0.97	58.2	2.88	mgd
13	0.9	0.69	37.3		
14	0.8	0.12	5.8		
15	0.8	0.17	8.16		
16		0	0		
17		0	0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)

Date: 11/26/2004 Time: 2:45 PM

Samplers: T. Brady

Staff Gauge Re 4.36 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min		
0	0.60	0.00	0		
1	0.80	0.00	0		
2	1.20	0.00	0		
3	1.20	0.00	0		
4	1.20	0.00	0		
5	1.30	0.00	0		
6	1.40	0.00	0		
7	1.20	0.35	25.2		
8	1.20	0.81	58.3		
9	1.00	0.68	40.8	355	cu ft/min
10	1.10	1.10	72.6	2655	gpm
11	1.10	1.12	73.9	3.82	mgd
12	1.00	1.02	61.2		
13	0.90	0.29	15.7		
14	0.60	0.20	7.2		
15	0.20	0.00	0		

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)

Date: 11/29/2004 Time: 1:30 PM

Samplers: T. Brady

Staff Gauge Re 4.98 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min
0	0.50	0.00	0
1	1.00	0.00	0
2	1.20	0.00	0
3	1.20	0.14	10.08
4	1.80	0.15	16.2
5	1.80	0.00	0
6	1.80	0.41	44.28
7	1.80	0.40	43.2
8	1.90	0.37	42.2
9	1.90	0.66	75.2
10	1.90	0.89	101.5
11	1.70	0.94	95.9
12	1.60	0.73	70.1
13	1.70	1.42	144.8
14	1.60	1.40	134.4
15	1.60	1.08	103.68
16	1.40	1.05	88.2
17	1.10	0.98	64.68
18	0.6	0.38	13.68
19	0.6	0.41	14.76
20	0.6	0.75	27
21	0.6	0.74	26.64
22	0.5	0.58	17.4
23	0.5	0.4	12
		1146	cu ft/min
		8572	gpm
	.	12.34	mgd

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)

Date: 12/12/2004 Time: 12:30 PM

Samplers: T. Brady

Staff Gauge Re 5.02 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min
0	0.50	1.91	57.3
1	1.80	2.88	311.04
2	1.00	2.05	123
3	1.00	2.03	121.8
4	1.20	2.91	209.52
5	1.20	2.95	212.4
6	1.60	2.61	250.56
7	1.00	1.85	111
8	0.60	2.48	89.3
9	0.60	1.41	50.8
10	0.00	0.00	0.0
11	0.00	0.00	0.0
12	0.00	0.00	0.0
13	0.00	0.00	0.0
14	0.00	0.00	0.0
15	0.00	0.00	0
16	0.00	0.00	0
17	0.00	0.00	0
18	0	0	0
19	0	0	0
20	0	0	0
21	0	0	0
22	0	0	0
23	0	0	0
24	0	0	0
		1537	cu ft/min
		11495	gpm
	.	16.55	mgd

NOTES:

measured at bridge/transection difficult due to rip-rap bottom

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)

Date: 1/14/2005 Time: 1:23 PM

Samplers: T. Brady

Staff Gauge Re 5.65 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min
0	0.00	0.00	0
1	1.10	0.30	19.8
2	1.30	0.30	23.4
3	1.50	0.36	32.4
4	1.60	0.64	61.44
5	1.80	0.86	92.88
6	2.10	1.11	139.86
7	2.20	1.26	166.32
8	2.20	1.12	147.8
9	2.30	1.10	151.8
10	2.20	1.66	219.1
11	2.20	1.68	221.8
12	2.20	1.66	219.1
13	2.30	1.09	150.4
14	2.20	1.06	139.9
15	2.20	0.96	126.72
16	2.40	0.78	112.32
17	2.40	0.86	123.84
18	2.2	0.73	96.36
19	2.1	0.35	44.1
20	2.1	0.26	32.76
21	2.2	0.17	22.44
22	2.1	0.15	18.9
23	1.6	0.15	14.4
24	1.7	0.15	15.3
25	1.4	0.12	10.08
		2403	cu ft/min
		17978	gpm
	.	25.89	mgd

NOTES:

Measurements made using moving instrument averaging technique.

Fish Brook Initiative - Streamflow Measurement Data Sheet

Location: FB-6 (Pumping Station)

Date: 12/12/2004 Time: 11:30 AM

Samplers: T. Brady

Staff Gauge Re 5.02 (feet)

Distance from Left Bank (feet)	Stream Depth (feet)	Average Velocity (feet/sec)	Discharge cu feet/min
0	0.20	0.00	0
1	0.40	0.00	0
2	1.00	0.00	0
3	1.50	0.00	0
4	1.90	0.13	14.82
5	2.00	0.21	25.2
6	1.90	0.24	27.36
7	1.90	0.39	44.46
8	2.00	0.51	61.2
9	2.10	1.36	171.4
10	2.00	1.21	145.2
11	1.80	0.43	46.4
12	1.80	1.42	153.4
13	1.80	1.49	160.9
14	1.80	1.43	154.4
15	1.60	1.02	97.92
16	1.50	0.99	89.1
17	0.80	0.83	39.84
18	0.9	0.71	38.34
19	0.7	0.65	27.3
20	0.8	0.52	24.96
21	0.8	0.7	33.6
22	0.6	0.52	18.72
23	0.6	0.15	5.4
24	0.6	0	0
		1380	cu ft/min
		10323	gpm
	.	14.86	mgd

NOTES:

Measurements made using moving instrument averaging technique.